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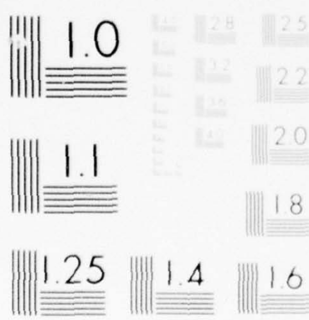

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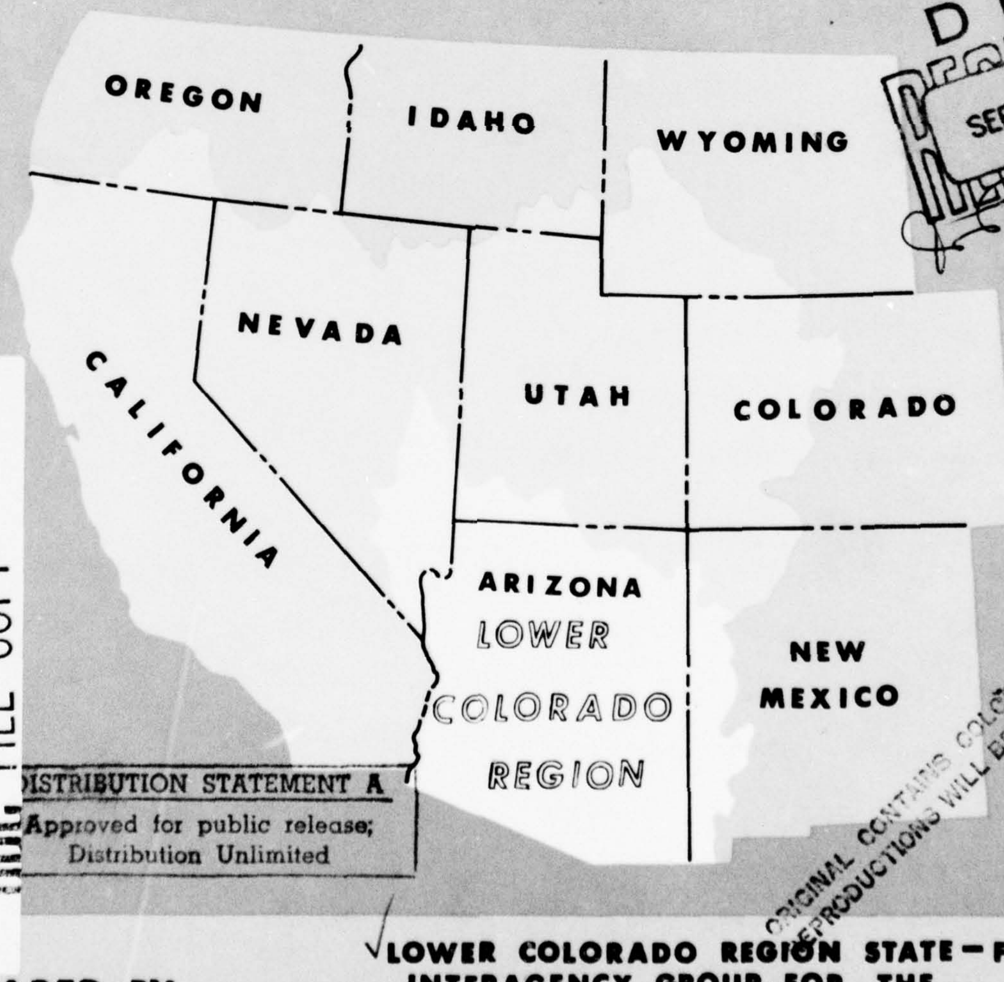
LOWER COLORADO REGION
Comprehensive Framework Study

APPENDIX XVIII
GENERAL PROGRAM AND ALTERNATIVES
JUNE 1971



PREPARED BY: LOWER COLORADO REGION STATE – FEDERAL INTERAGENCY GROUP FOR THE PACIFIC SOUTHWEST INTERAGENCY COMMITTEE

LOWER COLORADO REGION – Appendix XVIII
General Program and Alternatives – June 1971

APPENDIXES TO THE MAIN REPORT

LOWER COLORADO REGION

(11) June 71

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LOWER COLORADO REGION

COMPREHENSIVE FRAMEWORK STUDY.

APPENDIX XVIII. GENERAL PROGRAM AND ALTERNATIVES.

This report of the Lower Colorado Region Framework Study State-Federal Interagency Group was prepared at field-level and presents a framework program for the development and management of the water and related land resources of the Lower Colorado Region. This report is subject to review by the interested Federal agencies at the departmental level, by the Governors of the affected States, and by the Water Resources Council prior to its transmittal to the Congress for its consideration.

While the comprehensive framework plan presented herein is the result of a coordinated effort by participants from various Federal and State agencies involved in the Study, it does not necessarily reflect the singular viewpoint or policy of any particular agency or state. The type and need for future developments may change appreciably from the framework plan as a result of differing assumptions, methodology, and objectives used in water and land use plans prepared by the State and/or Federal agencies.

June 1971

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This appendix prepared by the

GENERAL PROGRAM AND ALTERNATIVES WORK GROUP

of the

LOWER COLORADO REGION STATE-FEDERAL INTERAGENCY GROUP

for the

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WATER RESOURCES COUNCIL

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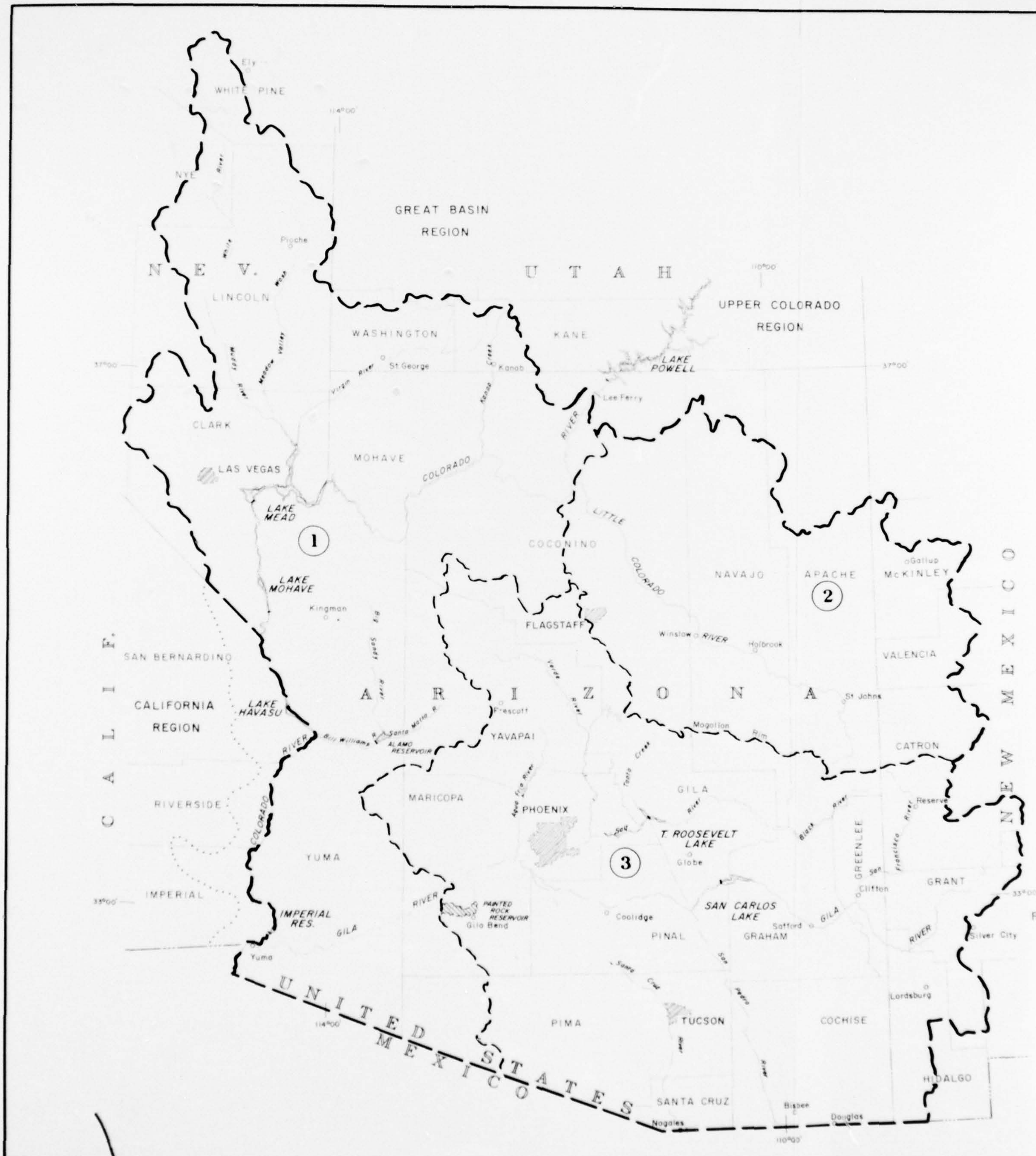
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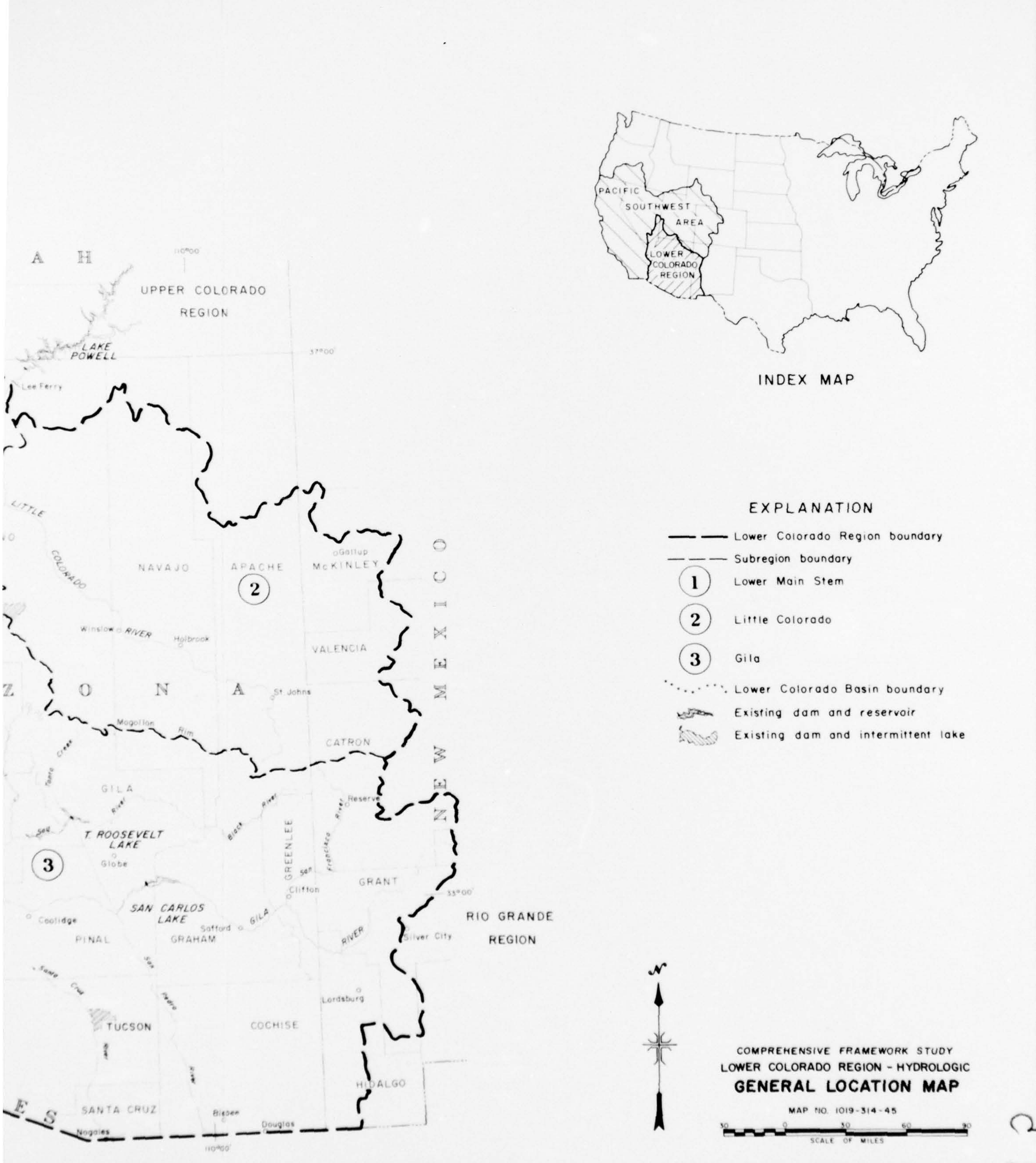
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Subregion boundary
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2 Little Colorado
3 Gila
Lower Colorado Basin boundary
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Existing dam and intermittent lake
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LOWER COLORADO REGION - HYDROLOGIC
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SCALE OF MILES

SUMMARY OF FINDINGS

The Lower Colorado Region includes most of Arizona, and parts of Nevada, New Mexico, and Utah comprising 4.8 percent of the contiguous United States. The Region is richly endowed with favorable climate, abundant land, mineral, and other resources and leads the Nation in population growth rate as well as in several other economic indices. The population is concentrated principally in central Arizona and the Las Vegas, Nevada areas. The remainder of the Region is sparsely settled and much is uninhabited.

Inventories and appraisals of resources and development of the Lower Colorado Region were prepared for a base year, 1965, and a 55-year projection time frame with three target years, 1980, 2000, and 2020. National interregional projections which equated national demand and supply together with consistent regional projections based upon historical trends in interregional production relationships, were developed by the Office of Business Economics, U. S. Department of Commerce, and the Economic Research Service, U. S. Department of Agriculture. These projections, referred to as OBE-ERS projections in this study, were based upon specific assumptions. A primary assumption was that the population of the United States will grow at the U. S. Census Series C rate which is substantially below the 1962-65 rate but above more recent rates. Other basic assumptions are included in this and the other functional appendixes relative to the particular resource aspect being considered. The OBE-ERS projections for the Region were modified somewhat to more closely reflect regional trends. These "Modified OBE-ERS" projections have been used in development of the Lower Colorado Region comprehensive framework program. A comparison of the Modified OBE-ERS and OBE-ERS projections is included in the latter part of Appendix IV, Economic Base and Projections.

Water Supply

Though land is abundant, the Region probably comes closer than most any other to utilizing the last drop of available water for man's needs. The Region's economy is sustained by utilizing ground-water reserves accumulated over thousands of years. In 1965, the depletion rate of these reserves reached 2.5 million acre-feet annually largely due to the lack of facilities for enabling the Region to utilize its unused share of Colorado River water. The ongoing Southern Nevada Water Project, presently under construction, the Central Arizona Project, and the Dixie Project in Utah must be completed at an early date in order for the Region to utilize the remainder of the available renewable water supplies. However, in the absence of an imported water supply, ground-water overdraft is expected to continue and the regional water deficiency is projected to reach 4.50 million acre-feet annually by

year 2020. Water resource-oriented programs need to be accelerated in the future with respect to both planning and implementation if future requirements are to be satisfied on a timely schedule. The basic long-range objective is augmentation of the Region's water supplies in sufficient increments to meet future water requirements and reduce ground-water overdraft. It is recognized that a program of this magnitude will probably require time, in the order of 20 years, to implement. In the meantime, all possibilities for lessening the effects of the increasing water deficiencies must be explored.

The framework program includes expansion of water conservation and management practices, more intensive water reuse, vegetative management for increased water yields, and treatment of brackish water. Vegetative management programs for increased water yield and water salvage programs are expected to add over 500,000 acre-feet annually to the local water supply by 2020. Further studies are needed to evaluate the potential of untapped ground-water reserves in remote basins to provide an interim water supply.

Implementation of the long-range program requires early initiation of planning for importing water to the Region. Studies should be included for evaluating the relative merits of all potential means of importation. Implementation of a water import program should be accomplished by year 1990 to provide about 2.25 million acre-feet. This should be increased to 4.15 million acre-feet by year 2020. The initial stage of the importation program would include the national commitment 1/ to relieve the Colorado River Basin States of the Mexican Treaty burden, estimated to be 1.8 million acre-feet annually including associated losses.

Table A-1 provides a summary of the present and projected water requirements and supplies.

Water Quality

Maintenance of an acceptable level of water quality is vital to the economy, environment, and general well-being of the people of the Region. Presently deficient water supplies and the probable cost of future imported water dictates maximum water utilization, including recycling, with little or no allowance for transporting salts or waste loads from the Region. The water quality program includes waste treatment facilities for urban centers, treatment of water from saline sources, and major water reuse facilities. Augmentation of the Colorado River

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1/ 90th Congress, Public Law 90-537, An Act to Authorize . . . the Colorado River Basin Project . . . , September 1968.

with high quality import water would have effects of major significance on improvement of the quality of this principal water source. Continuing studies of the Region's increasingly complex water quality problems are recommended.

Land Resources and Use

The land resource base of the Region appears to be sufficient in variety and amount to satisfy the projected land use requirements through the year 2020. There will need to be widespread adoption of the multiple-use principle in order to satisfy the requirements of all uses.

The following tabulation shows the major land use requirements for the period of study:

Use	Requirements - 1,000 Acres 1965	1980	2000	2020
Cropland	1,816	1,891	1,905	1,852
Irrigated	(1,785)	(1,863)	(1,882)	(1,833)
Nonirrigated	(31)	(28)	(23)	(19)
Livestock Grazing	76,054	73,739	69,902	65,807
Timber Production	5,458	5,358	5,153	5,044
Urban and Industrial	513	863	1,230	1,564
Outdoor Recreation (designated) 1/	5,542	5,888	6,012	6,146
Wilderness Areas	861	1,458	3,158	3,458
Fish & Wildlife (designated) 1/	3,223	3,546	7,175	15,020
Military	4,126	4,126	4,126	4,126
Transportation and Utilities	660	858	1,030	1,145
Water Yield Improvement	114	289	824	1,229
Flood Control	77	229	289	336
Mineral Production	76	115	156	223

1/ Designated: Lands which are administered primarily for the purpose but not precluding other activities which are compatible.

Land Treatment and Management

Irreversible losses of the Region's land resources must be minimized to preserve a freedom of choice for future resource users. Esthetic and environmental factors were of primary consideration in development of the program. Ideally, the land treatment and management program should harmonize with all water and related land resource development programs required to satisfy present and projected demands within the Region. On an equivalent acreage basis, as of 1965, a total of nearly 7 million acres of cropland, forest land, rangeland, and urban and other lands had received adequate treatment. The program

includes treatment of an additional 64 million acres by 2020. In most cases, the same acre will require treatment more than once during the study period because of development of improved methods, or the limited life of the measure or practice installed.

Flood Control

The Region is subject to severe and sudden floods, with some flood damage occurring every year. Almost all land suitable for general development is subject to some degree of flood damage, either from a defined stream or overland flow. The average annual flood damages were estimated at $41 million for 1965 economic and project conditions. With no additional flood control measures after 1965, annual flood damages of $310 million are estimated by the year 2020. Implementation of the flood control program of structural and nonstructural measures would effect damage prevention so that remaining damages of only $68 million annually are estimated by the year 2020. For these remaining damages there appear to be no feasible solutions.

Irrigation and Drainage

Irrigated land is expected to increase from the 1965 level of 1,315,000 1/ to 1,613,000 acres. Urbanization is expected to remove 204,000 acres from production. The total new irrigation development would be 502,000 acres. The program includes completion of the rehabilitation of existing water conveyance systems for 429,000 acres of presently irrigated lands and new distribution systems to serve 1,075,000 acres, a portion of which is presently irrigated exclusively from ground water. Onfarm water management measures such as land leveling and water control structures are recommended for about 2.2 million acres during the study period. The 2.2 million acres include retreatment of some land because of the expected improved technology and limited life of the structures and measures. These measures are to provide better control and more efficient use of irrigation water and/or to reduce costs of irrigation. New drainage facilities are included to serve 188,000 acres.

Municipal and Industrial Water

The rapidly increasing population will require that water for municipal and industrial uses be increased from a 1965 level of 450,000 acre-feet to 2.8 million acre-feet in year 2020. Presently authorized projects will supply 446,000 acre-feet of additional water

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1/ Includes only those acres actually irrigated in 1965 plus the acreage double cropped.

by 2000. Major urban centers would satisfy their additional water requirements through the importation program and through treatment and recycling of waste water for some uses. Smaller communities would fulfill their increasing needs by a variety of means, including further surface- and ground-water development, desalting of brackish ground water, and by importation.

Mineral Resources

Adequate mineral resources are available to meet the expected increased production, $511 million in 1965 to $1.93 billion in year 2020 (1958 dollars). Water withdrawal requirements would increase from 105,100 to 357,200 acre-feet in this period while land requirements would increase from 76,000 acres to 223,000 acres. Environmental impacts of the mining and processing of ores will need to be minimized, especially with respect to air and water pollution, ecology and esthetics. Water requirements of the mineral industry may be met by direct diversion of imported water; by upstream developments on the basis that downstream rights would be met by exchange for imported water; or by continued ground-water development, where available.

Recreation

Recreation needs of the Region, above available supply, are projected to increase from 144 million recreation days in 1965 to 672 million recreation days in 2020. Under existing legal, institutional, financial, and physical constraints only about 42 percent of these needs can be met. To satisfy the remaining 58 percent of the needs will require elimination or modification of these constraints and a greater degree of Federal participation.

Water-based recreation needs will climb to 193 million recreation days annually by 2020. Maximum water augmentation, development and use, under the framework plan will supply a part of the water-based recreation needs.

Land acquisition in the amount of 60,000 acres will be required to satisfy the non-Federal recreation needs.

Fish and Wildlife

The annual demand for fishing would increase from a 1965 level of 4.0 million man-days to 26.0 million man-days in year 2020. Multi-purpose developments authorized to be constructed by 1980, including the Alamo, Dixie, and Central Arizona Projects, have the potential to provide 1.2 million man-days of fishing annually. Numerous smaller fishing reservoirs are planned for construction by state and Federal agencies and many Indian Tribes that are expected to provide 2.0 million man-days of fishing annually by 1980. After 1980, proposed water

development, primarily multipurpose, are expected to provide an additional 1.02 million man-days annually by 2020. To satisfy fishing demands not met by the above developments, the fish and wildlife program provides for additional fishery developments in 1980, 2000, and 2020 that would provide a total of 16.0 million man-days of fishing annually by year 2020.

The demand for hunting is expected to increase from a 1965 level of 1.3 million man-days to 5.1 million man-days annually in 2020. A primary concern in satisfying the demands for wildlife resources is the preservation and improvement of existing habitat. In the Lower Colorado Region, most of the valuable wildlife habitat is on lands administered by public agencies, thus providing significant opportunities for further wildlife development. Satisfying a part of the demand for fish and wildlife resources and achieving optimum multiple-use of public lands is dependent upon improving the existing habitat and accelerating development to increase fish and wildlife production.

Also, satisfying future demands for fish and wildlife resources will require that 11.8 million acres of selected areas consisting mostly of public lands be managed to yield maximum fish and wildlife values. The areas would be managed with emphasis directed to the production of fish and wildlife, with appropriate consideration of compatible and/or complementary uses. The construction of access facilities and numerous wildlife watering facilities is included in the fish and wildlife program.

Electric Power

Electric power requirements are expected to increase by fortyfold between 1965 and 2020. These requirements would need to be met partially by construction of power facilities within the Region and partially by imports from other areas. The regional water requirement for power production would increase from 9,600 acre-feet in 1965 to 434,700 acre-feet by year 2020. The increased water use would be supplied largely by imported water supplies.

Environmental Considerations

The comprehensive nature and interrelationship of environmental problems have recently become widely recognized. The Region's rapid population growth rate, its concentration in only a few locations, the fragile nature of the desert environment, and the extremely limited water supplies,require particular attention to the environmental impacts which may occur as the result of development necessary to insure the well-being of the people of the Region. Such considerations have been of paramount concern to planners in nearly every phase of the framework studies. Main items of concern include: preservation of cultural, scenic, and natural values; protection and management of land resources;

safeguarding the quality of water supplies; maintenance of agricultural areas; enhancement of fisheries; and the preservation of wildlife habitat.

Summary of Projected Demands and Framework Program

Table A-2 summarizes the Region's gross demands for water-related functions and services. Table A-3 summarizes the regional framework program for the development of water and related land resources needed to satisfy projected requirements and Table A-4 shows the needs unmet by the framework program.

Table A-1
Summary of Water Requirements and Supply
1965-2020

	1965	Total Annual Demand 1980	2000	2020
Water Requirements				
Withdrawals (1,000 Acre-Feet)				
Reservoir Evaporation 1/	230	286	328	359
Municipal and Industrial	450	863	1,703	2,778
Irrigation	9,138	9,429	8,496	8,405
Recreation	11	21	41	70
Fish and Wildlife	196	214	325	556
Electric Power Cooling	10	37	106	435
Mining	105	176	264	357
Total	10,140	11,026	11,263	12,960
Depletions (1,000 Acre-Feet)				
Reservoir Evaporation 1/	230	286	328	359
Municipal and Industrial	198	358	677	1,149
Irrigation	4,626	5,326	5,312	5,381
Recreation	4	7	14	24
Fish and Wildlife	110	142	232	405
Electric Power Cooling	10	37	107	435
Mining	52	89	135	185
Losses Associated with Recycling and Reuse	600	640	460	580
Total	5,829	6,885	7,265	8,518
Water Supply Without Augmentation (Unit: Million Acre-Feet)				
Colorado River Water Available for Use in Lower Colorado Region	2.63	2.25	1.33	0.90
Local Water Supply	3.12	3.12	3.12	3.12
Total Supply Available for Use in the Lower Colorado Region 2/	5.75	5.37	4.45	4.02
Lower Colorado Region Depletion Requirements	5.83	6.88	7.26	8.52
Regional Water Deficiency 3/	0.08	1.51	2.81	4.50

Table A-1 (Continued)
Summary of Water Requirements and Supply

	1965	Total Annual Demand 1980	2000	2020
Water Supply with Augmentation (Unit: Million Acre-Feet)				
Colorado River Available for Use in Lower Colorado Region	2.63	2.25	1.33	0.90
National Obligation to Mexican Water Treaty 4/	--	--	1.80 3/	1.80 3/
Local Water Supply	3.12	3.12	3.12	3.12
Total Supply Available for Use in Lower Colorado Region 2/	5.75	5.37	6.25	5.82
Lower Colorado Region Depletion Requirements	5.83	6.88	7.26	8.52
Regional Water Deficiency 3/	0.08	1.51	1.01	2.70
Regional Augmentation 5/	____	0.03	0.57	2.53
Remaining Deficiency 6/	0.08	1.48	0.44	0.17

1/ Excludes mainstream Colorado River reservoir evaporation accounted for in the determination of availability of Colorado River water.

2/ Excluding ground-water overdraft.

3/ Lack of facilities prevented utilization of the Region's full share of Colorado River water resulting in a ground-water overdraft of about 2.5 million acre-feet. In the future to limit the water supply deficiency to that tabulated would require: distribution of the available supply to areas of shortage, total utilization of the resource including recycling,and that no allowance be made for transporting salts from the Region.

4/ Consists of 1.5 million acre-feet per annum for delivery to Mexico plus an estimated 0.3 million acre-feet associated losses. In accordance with Public Law 90-537, Section 202, "The Congress declares that the satisfaction of the requirements of the Mexican Water Treaty from the Colorado River constitutes a national obligation which shall be the first obligation of any water augmentation project planned pursuant to Section 201 of this Act and authorized by Congress."

5/ As recommended in the Lower Colorado Region framework program.

6/ To be supplied by ground-water overdraft.

Table A-2
Gross Needs for Water Related Functions and Services

	1965 Base	Total Annual Need 1980	2000	2020
Flood Damage Prevention ($ Million)	41	73	152	310
Wildfire Damage Prevention ($ Million)	6	8	13	20
Erosion Damage Prevention ($ Million)	7	11	17	24
Outdoor Recreation (Million Recreation-Days)	138	268	540	918
Sport Fishing (Million Man-Days)	4	10	15	26
Hunting (Million Man-Days)	1.3	2.1	3.5	5.1
Irrigation (1,000 Acres)	1,315	1,488	1,579	1,613
Drainage (1,000 Acres)	212	280	312	400

Table A-3
Framework Program for Development of Water and Related Land Resources
Lower Colorado Region
(Increments in Each Time Frame)

	Units	1966-1980 Quantity	1966-1980 Cost (Million Dollars)	1981-2000 Quantity	1981-2000 Cost (Million Dollars)	2001-2020 Quantity	2001-2020 Cost (Million Dollars)
A. WATER RESOURCE PROGRAM (streamflow control and inplace use)							
1. Reservoir storage for withdrawal and inplace use	million acre-feet	3.71	46	1.32	132	0.28	30
2. Flood Control			359		337		248
(a) Reservoir and detention storage	million acre-feet	3.15	(228)	0.60	(98)	0.65	(147)
(b) Levees and channel improvement	miles	859	(110)	455	(205)	245	(56)
(c) Nonstructural measures		--	(15)	--	(24)	--	(34)
(d) Land Treatment	thousand acres	188	(6)	280	(10)	265	(11)
3. Augmentation of Regional Water Supply	million acre-feet per year		787		4,225		3,373
(a) Imports to the Region	million acre-feet per year	--	--	2.25	(3,600)	1.90	(3,000)
(b) Water slavage	million acre-feet per year	0.30	(42)	--	--	--	--
(c) Precipitation management	million acre-feet per year	--	--	--	--	--	--
(d) Water yield improvement	million acre-feet per year	0.03	(16)	0.09	(33)	0.06	(35)
(e) Intraregional transfers	million acre-feet per year	1.67	(729)	3.00	(592)	1.08	(338)
4. Water Quality, Pollution Control, and Health Factors	million gallons per day		126		108		327
(a) Waste water treatment	million gallons per day	270	(91)	440	(102)	530	(165)
(b) Quality and pollution control	million gallons per day	268	(35)	320	(6)	510	(2)
(c) Drainage water treatment	million gallons per day	--	--	--	--	150	(160)
5. Single-purpose M&I Water Supply Development	million acre-feet per year	0.41	109	0.83	279	1.07	140
6. Hydroelectric Power (pumped storage)	million kilowatts per year	0.8	76	3.7	377	9.1	324
TOTALS, WATER RESOURCE PROGRAM COSTS			1,503		5,458		5,042
B. RELATED PROGRAMS							
1. Land Treatment and Management	thousand acres	18,425	156	27,026	305	16,745	159
(a) For water yield improvement (see item A.3.(d)above)	thousand acres	(250)	(--)	(600)	(--)	(450)	(--)
(b) For erosion, sediment, and runoff control	thousand acres	(18,175)	(156)	(26,426)	(305)	(16,295)	(159)
2. Irrigation and Drainage	thousand acres		248		277		162
(a) Land preparation, onfarm facilities	thousand acres	573	(56)	801	(78)	779	(76)
(b) New distribution systems	thousand acres	347	(108)	596	(184)	132	(41)
(c) Rehabilitation of existing distribution systems	thousand acres	429	(70)	--	--	--	--
(d) Drainage developments	thousand acres	68	(14)	32	(15)	88	(45)
3. Outdoor Recreation (water-based developments)	million recreation days	0	0	26	107	9	38
4. Fish and Wildlife	thousand man-days	4,022	51	7,014	114	11,794	208
5. Wild and Scenic Rivers 1/	miles	1,080	--	--	--	--	--
TOTALS, RELATED PROGRAM COSTS			455		803		567
C. OTHER ASSOCIATED PROGRAMS							
1. Land Treatment and Management	thousand acres	7,409	43	9,410	99	6,840	48
2. Outdoor Recreation (additional development and land acquisition)	million recreation days	51	194	93	338	106	375
3. Fish and Wildlife	thousand acres	331	1	3,629	1	7,845	1
4. Preservation of Cultural and Scenic Values 1/ Wilderness Areas	thousand acres	2,762	--	1,700	--	300	--
5. Other Electric Power	million kilowatts		739		5,000		16,000
(a) Thermal power	million kilowatts	1.9	(229)	22.8	(2,600)	77.8	(10,000)
(b) Transmission facilities		--	(510)	--	(2,400)	--	(6,000)
TOTALS, OTHER ASSOCIATED PROGRAM COSTS			977		5,438		16,424

1/ Areas requiring further study to define required scope of development.

Table A-4
Remaining Needs Unsatisfied by Framework Program 1/

	Annually at End of Time Frame		
	1980	2000	2020
Water Supply (Million Acre-Feet)	1.48	0.44	0.17
Flood Damage Prevention ($ Million)	41	50	68
Recreation (Million Recreation-Days)	93	101	192
Wildfire Damage Prevention ($ Million)	7.4	9.7	12.0
Erosion Damage Prevention ($ Million)	8.2	7.0	6.3

1/ Not included for lack of practicable solutions and legal and institutional constraints.

LOWER COLORADO REGION COMPREHENSIVE FRAMEWORK STUDY

APPENDIX XVIII

GENERAL PROGRAM AND ALTERNATIVES

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PHOTOGRAPHS

The photographs utilized in this report were selected from a large collection supplied by participants in the study. The following contributors and others are gratefully acknowledged:

National Park Service
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Soil Conservation Service
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Bureau of Sport Fisheries and Wildlife
Corps of Engineers
Bureau of Land Management
Bureau of Indian Affairs
Bureau of Reclamation

INTRODUCTION AND DESCRIPTION OF THE REGION

CHAPTER A - INTRODUCTION AND DESCRIPTION OF THE REGION

The General Program and Alternatives Appendix utilizes the findings of 15 separate, functional appendixes which are listed on the inside front cover.

Generally, the functional appendixes analyze the present status of the Region's socio-economic environment; define the current sufficiency and deficiency of the available resources; project trends of development and needs through the year 2020; and recommend means of satisfying future needs and/or enhancing the future environment.

In this appendix, the studies set forth in the other appendixes are analyzed and integrated into a comprehensive framework program that appears to be the most reasonable for achieving the Region's economic, social, and environmental goals.

Objectives of Framework Studies

In accordance with Senate Document No. 97 1/, a principal objective in water resource planning "is to provide the best use, or combination of uses, of water and related land resources to meet all foreseeable short- and long-term needs." To accomplish this in an expanding economy, the framework studies analyze past accomplishments and present and future requirements and compare them with the available water and related land resources to develop a program for the efficient satisfaction of projected demands.

To be most effective as guides for action programs and to serve as a sound base for a continuing planning process, framework studies should be both broad in coverage and flexible in structure so that additional alternative courses of action may be examined, evaluated, and instituted as desirable or necessary. Development of the Lower Colorado Region framework program has been accomplished with these planning goals and reporting objectives in mind.

The economic and social welfare of the Nation and its component regions, including the Lower Colorado Region, depends on many complex factors. Water resources, while being the dominant concern in the Lower Colorado Region, cannot be singled out as the sole vehicle for

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1/ Policies, Standards, and Procedures in the Formulation, Evaluation, and Review of Plans for Use and Development of Water and Related Land Resources. 87th Congress, 2nd Session.

these welfare features. Nevertheless, water can be readily established as a commodity that cannot be foregone if industry, agriculture, and the modern way of life in the Lower Colorado Region are to be enhanced. Water supports life, floods our lands, nourishes and washes our food, carries away our wastes, provides water playgrounds, enhances wildlife, cools and supports our industrial activities, and in many ways, supports and provides unique services to man and his activities.

Our expanding economy and changing social goals place increasing pressures on the already highly developed water and related land resources of the Region. These resources have finite limits which vary considerably in quality, quantity, and distribution throughout the Lower Colorado Region. Accordingly, steps must be taken to assure that these resources are available in quality, quantity, and location and at the time needed to supply the services and products required by the economic and social objectives of the Region. Wise choices of use are required now and in the future to assure this availability of resources.

Steps to be taken in effecting the regional choices may include: (a) structural measures to control streamflows; (b) nonstructural programs to preserve environmental values, control the use of groundwater resources, manage the uses of flood plains, provide flood warning services, manage and treat land resources; or (c) combinations of structural and nonstructural measures under multipurpose programs.

The objectives of the framework studies are to explore in depth the goals and choices to be made to effect an optimum water and land development program. This program would utilize the resources to provide the products and services required to support and promote economic growth and social betterment at national, regional, and local levels.

Authorization

The Lower Colorado Region is one of the major river basins in the United States included in the national program. Comprehensive river basin plans for the development, use, and management of the water and related land resources of the Nation are the main objective. This national program stemmed from recommendations of the Senate Select Committee on National Water Resources, and planning concepts are embodied in Senate Document No. 97, 87th Congress, Second Session. The overall program was presented by the President in the Fiscal Year 1963 budget. The Lower Colorado Region study was approved by Congress, and funds were provided to start this activity in Fiscal Year 1967.

The Water Resources Planning Act (P.L. 89-80, July 22, 1965) established the Water Resources Council. The President transferred the functions and committee organization of the Interagency Committee on

Water Resources to the Water Resources Council on April 10, 1966. This transfer included the Pacific Southwest Inter-Agency Committee. By letter of October 10, 1966, the Water Resources Council requested the Pacific Southwest Inter-Agency Committee to take leadership and coordinate the comprehensive studies in the Pacific Southwest, including the Lower Colorado Region. PSIAC accepted this responsibility by letter of November 21, 1966. An organization meeting to begin the Lower Colorado Region study was held on February 8, 1967. The Department of the Interior was designated to be lead agency and the Bureau of Reclamation provides chairmanship of the Lower Colorado Region State-Federal Interagency Group and Staff.

The States of Arizona, California, New Mexico, Nevada, and Utah are participating with the various Federal agencies in this investigation.

At the Federal level, the various participating departments and agencies operate under numerous specific authorities which are listed in Appendix III--Legal and Institutional Environments.

Scope

This study deals with the water and related land resources of the Lower Colorado Region and embraces all significant problems and beneficial uses associated with these resources. Consideration was given to various aspects of problems related to supplies of water for municipal and industrial purposes, water quality control, flood control, irrigation, electric power production, mining and mineral processing, watershed management and treatment, land resources and use, outdoor recreation, and fish and wildlife habitat. Environmental aspects such as natural beauty, cultural and historic values, rare species of flora and fauna, wildlife in general, and quality goals are considered to be integral parts of the fabric of an optimum framework program.

Investigations in the Lower Colorado Region cover parts of the States of Utah, Nevada, Arizona, and New Mexico.

The study covers the period from 1965 (base year) to the year 2020. In order to identify and stage early, intermediate, and late action programs, the study period was divided into three time frames: 1965-1980, 1981-2000, and 2001-2020.

In addition to the 1965 base level of development, there are substantial authorized programs which have been recognized in the early action framework program.

Study Approach

For the purpose of this study, the Lower Colorado Region was divided into three hydrologically delineated subregions; and to accommodate the

socio-economic statistical analysis, the Region and subregions were extended to the closest fitting political boundaries. The latter delineations were designated the economic region and the economic subregions. All base year projections of factors were adjusted to represent the hydrologic areas except where otherwise noted. Investigations were first conducted by subregions. These subregional studies were then coordinated, interrelated, and summed up to obtain the overall program for the Lower Colorado Region.

The study program consists of three basic elements:

(a) Evaluation of present and projected needs for goods and services which place a demand on water and related land resources;

(b) Evaluation of resources, including those in authorized and potential programs, which will become available to serve the demands; and

(c) Formulation of a general Lower Colorado Region framework and development program to serve short- and long-term needs.

To fully utilize the capabilities of Federal and State agencies with expertise in all fields of planning, work groups were established to deal with each of the appendixes required to support this appendix. Generally, the chairmanship in each work group was vested with the agency having the most appropriate background related to the function. In all, 16 appendixes were developed, as listed on the front cover of this appendix.

The Lower Colorado Region Staff, under the leadership of the Department of the Interior, reviewed the progress of the work groups, resolved coordination problems, ascertained that policies and study rules were being followed, and made recommendations on study procedures and policies.

Coordination

To adequately cover all technical aspects of this comprehensive study and to enlist the viewpoints of all the Federal, State, and local interests, many agencies have been actively engaged in the framework program.

Federal agencies exchanged information and coordinated their work directly among themselves and with appropriate State agencies. Periodic joint meetings of the Federal and State agencies were held at field level to review findings and to exchange data and views.

Planning Policies and Constraints

In the course of this broad, comprehensive investigation, it was necessary to make numerous general and specific assumptions to limit the number of possibilities of direction and magnitude of the various socio-economic projections. Among the major controlling assumptions and constraints are the following:

A. For the duration of the study period, there will be no catastrophic wars, no national political upheaval, no major economic depressions, or any other environmental changes that would upset the projected socio-economic trends.

B. No constraints are to be considered on the amount of goods, services, and resources required to support the projected levels of economic activity.

C. The following assumptions governed consideration of interregional transfers of water:

1. All existing diversions are to be recognized and the expected transfers of water included as a loss to the transferring-out region and available for use in the transferring-in region.

2. All actively authorized projects for interregional diversions are to be treated as in 1 above.

3. All water subject to distribution among regions in accordance with existing compacts and Court decisions is to be distributed in accordance with their provisions. In some cases, this requires a decision as to the future division of water among regions within a state.

4. The ocean is considered available to the Lower Colorado Region and plans for its use as a water resource are included.

D. Allocation of Water Among Competing Areas/Uses.

Assumptions concerning allocation of water among competing areas and uses are of paramount concern. Historically, in the West, water has been appropriated for use under state law. It is expected that future uses will be sanctioned under similar jurisdictional arrangements. Established water rights have inherent economic value and are normally associated with beneficial use on specific land or property. The history of the West and western water law records the extreme sensitivity of the questions associated with allocation of water resources

among competing areas and uses. In some situations where water has been diverted from one use to another use either by court action or by purchase, severe social and public relations problems have developed. These complex questions and issues cannot be ignored nor can they realistically be greatly simplified.

Experience has shown that expanding urban areas almost always have adequate capacity to pay whatever reasonable cost is involved in obtaining a supplemental water supply. The technology of water project development, waste water treatment, and saline or brackish water conversion is sufficiently advanced that it is reasonable to assume that adequate "new" water supplies can be made available for supplemental service to urban areas at costs within the user's ability to pay.

In recognition of the foregoing, it was concluded that the following basic assumptions were necessary in Type I planning:

1. Water presently being beneficially used will not be diverted to supplement growing urban or industrial demands, except where urban or industrial growth occupies land on which water was previously beneficially used for another purpose, in which case it will be assumed that the water supply will be transferred with the land to the new use.

2. Allocation of newly developed water supplies will be predicated on the projected demands for commodities, services, and other purposes.

3. Available water allocated under compacts, agreements, or laws but not presently in beneficial use by the allottee will be available for future beneficial use of the allottee (state or other organization unit). Each of the regions will rely on appropriate state laws for determination of priorities of use among competing areas and uses.

4. Plans will be made, if possible, for replacement of water presently being beneficially used but for which there is a legally established adverse claim, such as rights under area of origin, statutes and interstate compacts.

E. Water Quality Criteria.

The study assumes the application of all possible technically and economically feasible means to preserve the quality of the water resources of the Region. As a result, future growth and full development of water use under existing compacts, decrees, or intrastate water rights will not be inhibited.

F. Projections of Regional Growth.

Projections of regional growth and development are generally constrained in this study in accordance with the national projections that were developed by the Departments of Agriculture and Commerce (Economic Research Service and Office of Business Economics) and supplied to the Region by the Water Resources Council. These projections were modified by the States of the Lower Colorado Region to reflect local conditions and trends.

G. Environmental Policy and Constraints.

Recognizing the impact of man's work on the environment, the National Environmental Policy Act of 1969 establishes the policy of promoting efforts to prevent or minimize damage to the environment, and of enriching the understanding of the ecological systems and natural resources of the Nation. Generally, the philosophy of the Act has been pursued in developing the framework program.

The maintenance and/or enhancement of the environment of the Region extends into every segment of the framework study. In each of the functional segments of the study, environmental programs have been considered on a comprehensive basis rather than on a single-purpose basis.

H. Land Use.

All land be used in accordance with its capabilities and be given conservation treatment in accordance with its needs as they arise in connection with such use. Utilization of all lands will be made and competition will cause major shifts in land use within land capabilities. The "related lands" under consideration in this study are as defined in the Water Resources Council's Guidelines.

Area of Study

The Lower Colorado Region includes a large portion of Arizona and parts of Nevada, Utah, and New Mexico, and has a total area of 141,000 square miles. See General Location Map, Lower Colorado Region (Frontispiece).

The hydrologic region is bounded on the east by the Continental Divide in New Mexico, on the west by a part of Nevada and the State of California, on the south by Mexico, and on the north by the hydrologic boundary at Lee Ferry, Arizona.

Desert Lowlands

Forested Plateau Lands near Flagstaff, Arizona

INTRODUCTION

The Region is naturally divided into three major drainage areas which are designated as hydrologic subregions, namely: Lower Main Stem, Little Colorado, and Gila.

The Lower Main Stem Subregion encompasses 56,554 square miles of which 35,754 square miles are located in western Arizona, 17,310 square miles are in southern Nevada, and 3,490 square miles are in the southwest corner of Utah. Included in the Subregion are the cities of St. George, Utah; Las Vegas, Nevada; and Yuma, Arizona.

The Little Colorado Subregion is comprised of the entire drainage area of the Little Colorado River which is located in the northeastern part of the Lower Colorado Region. The Subregion includes 21,667 square miles of Arizona and 5,310 square miles of New Mexico for a total of 26,977 square miles. The cities of Gallup, New Mexico; Flagstaff, Holbrook, and Winslow, Arizona, are included.

The Gila Subregion encompasses 57,606 square miles of which 49,561 square miles lie in Arizona and 8,045 square miles are in New Mexico. The area is bounded on the east by the Continental Divide and on the south by Mexico, and on the north and west by the hydrologic boundaries of the Gila River Basin. Included in the area are the cities of Phoenix and Tucson, Arizona; and Lordsburg, New Mexico.

Land Forms and Geology

The Lower Colorado Region is composed of a complex of plateaus, mountains, canyons, deserts and plains, with elevations ranging from 75 feet above sea level, near Yuma, Arizona, to over 12,600 feet above sea level at Humphreys Peak, near Flagstaff, Arizona. The topography takes in virtually every form and degree from level plains to precipitous mountains and canyons between these elevation extremes.

Similarly, the geology of the Region includes a broad spectrum of sedimentary, metamorphic and igneous rocks which produce a wide variety of soils locally and along stream courses. In short, principal physical characteristics of the Region are its variety of land forms, topography, and geology.

Resources

Suitable land is available for each land use when considered individually. In order to help satisfy the requirements for all uses, there will need to be widespread adoption of the multiple-use principle. Unfortunately, the development of the land for agriculture is curtailed in many cases by the lack of economical water and the regional choices for all water-based development have become very competitive. Limited renewable water supply is another characteristic of the Region.

Canyon Country at Toroweap Point, Grand Canyon National Monument

Mountain Grass and Woodlands

Although some minerals are currently uneconomical to mine, minerals are available in many categories in sufficient quantity to meet the development needs in the Region.

Climate

Climate in the Lower Colorado Region varies as widely as its land forms and topography. Maximum temperatures range from more than 100 degrees in the desert areas to mild 70's in the mountains. In some mountainous areas, minimum temperatures sometimes drop to 30 degrees below zero. Frost-free periods range from less than 60 days in the high mountains to almost year-long in the desert valley areas. Annual precipitation varies from an average of less than 5 inches at Yuma to more than 30 inches in the higher mountain ranges. The combination of high temperatures and low humidity in the desert areas causes high rates of evaporation and transpiration and results in the loss of more than 95 percent of the annual precipitation. See Figure 1 for general climatic data.

The People

The Region's population growth rate is currently leading the Nation with Nevada ranking No. 1 and Arizona No. 3 in the national rating. Racial distribution is similar to that of the Nation except that the Indian population is 7 percent compared to 0.3 percent nationally.

Education of the people of the Region compares favorably with the national average in most levels except that in the Region there are slightly more people having no schooling and slightly more completing at least 4 years of college.

The 1965 personal per capita income in the Region averaged about $2,292 or 90 percent of the national figure.

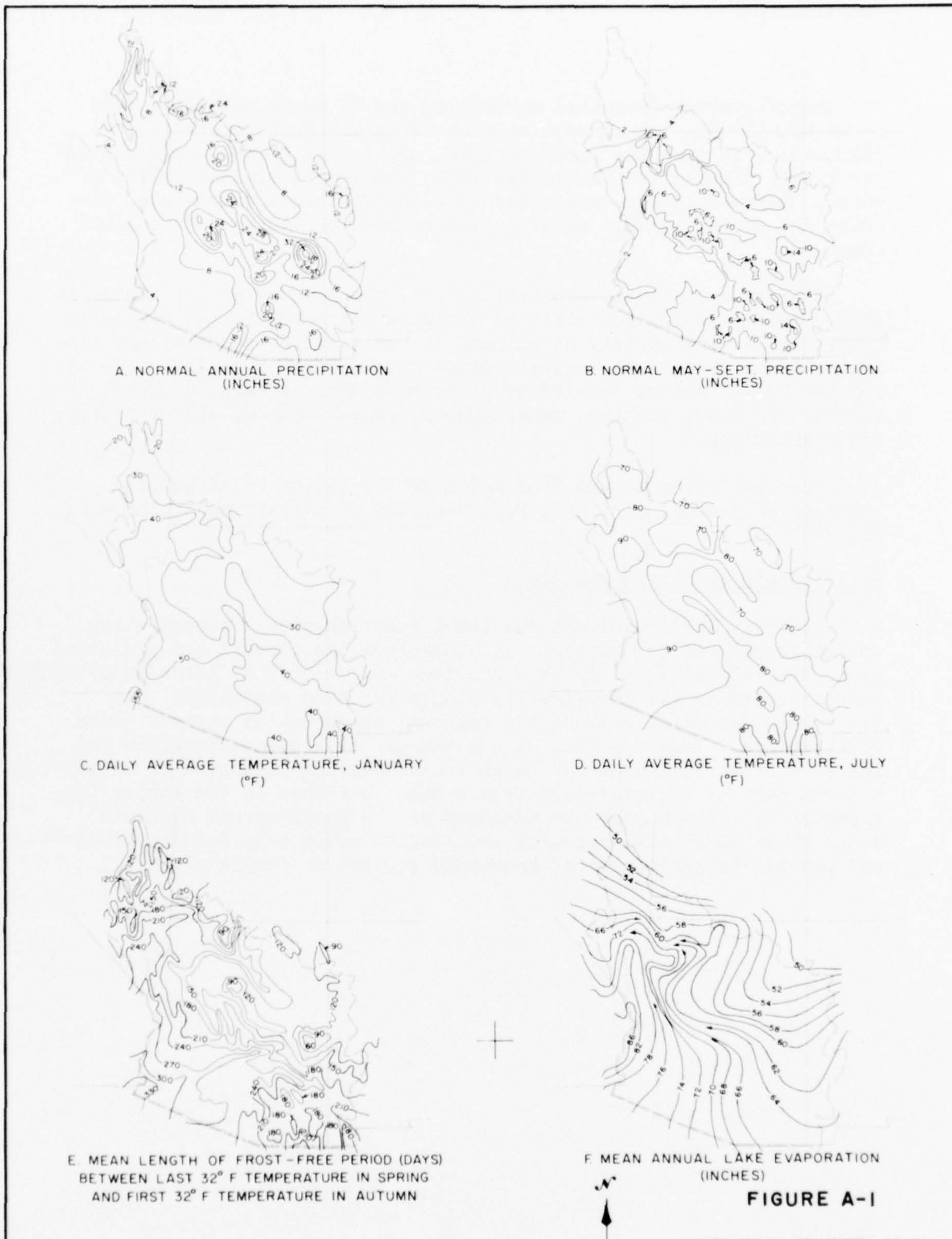
Development

The irrigated lands represent about 98 percent of all cultivated lands in the Region. About 1.2 million acres of land are irrigated, mostly in the southern desert areas where long growing seasons and climate favor a wide variety of crops.

Mining is one of the leading industries in the Region. Along with many other minerals, about 60 percent of the Nation's copper supply was mined in the Region in 1965.

The combined regional electric power organizations in 1965 were supplying the Region's needs and were engaged in the exchange of large blocks of power with power organizations outside the Region. Construction is planned or underway to enlarge the power generation capacity.

Las Vegas, entertainment capitol of the southwest, contributes significantly to the economy of the Region. Over 13,000,000 visitors spent $350,000,000 in 1965.



A. NORMAL ANNUAL PRECIPITATION (INCHES)

B. NORMAL MAY-SEPT. PRECIPITATION (INCHES)

C. DAILY AVERAGE TEMPERATURE, JANUARY (°F)

D. DAILY AVERAGE TEMPERATURE, JULY (°F)

E. MEAN LENGTH OF FROST-FREE PERIOD (DAYS) BETWEEN LAST 32° F TEMPERATURE IN SPRING AND FIRST 32° F TEMPERATURE IN AUTUMN

F. MEAN ANNUAL LAKE EVAPORATION (INCHES)

INTRODUCTION

Manufacturing increased tenfold in the 20 years preceding 1965 to an annual value of about 2 billion dollars. Most important, regionally, is that the manufacturing industry is largely composed of the light, diversified, smokeless type, and uses a minimum amount of water. Representative categories include electrical components, aircraft and parts, primary metal products, food products, printing and chemicals.

Tourism contributed substantially to the economy of the Region in 1965. Nearly 30 million visitors who were attracted to the Region in 1965 found a wide variety of climates to suit their tastes at any time of the year. They found entertainment ranging from a lavish scale at the Las Vegas casinos to outdoor activities such as camping, golf, boating, hunting, fishing, water sports, rock-hounding, winter sports, and sightseeing.

Transportation to and from parts of the Region is adequately provided by railroads, airlines, buslines, and interstate and international highways.

Relationship to Other Appendixes

Appendix XVIII outlines the significant physical, economic and social aspects of the Region. It summarizes the present and projected water and related land resource problems and functional needs as developed and discussed in the 15 primarily single function appendixes. It determines the capability of the regional resources to satisfy these requirements. This appendix also suggests development programs and implementation action needed which would have the potential of satisfying a large part of the projected future needs outlined in the supporting appendixes. It analyzes the adequacy of the programs and suggests areas where additional research and studies could help resolve problems and provide better technical knowledge for use in future planning.

PRESENT STATUS OF DEVELOPMENT

CHAPTER B - PRESENT STATUS OF DEVELOPMENT

ECONOMY

Characteristics of the Population

The Lower Colorado Region is a part of the fastest growing area in the United States. In 1965 the estimated population was 1,877,000 (Economic Region). This represents a growth of slightly over 300 percent in the last 25 years. About 45 percent of the 1965 population of the Lower Colorado Region was concentrated in three major cities: Las Vegas, Nevada; and Phoenix and Tucson, Arizona. In 1960, the last census year with published census data, 73.7 percent of the population was classified as urban and only 26.3 percent as rural.

Employment and Personal Income

The past and present employment within the Lower Colorado Region is shown in Table B-1. Figure B-1 presents graphic representation of regional employment by industries in 1965. The rapid growth of employment in the Region is evident when compared with that of the Nation. The Lower Colorado Region, for example, recorded an 82 percent increase between 1950 and 1960, compared to approximately 14 percent increase for the Nation. Estimates for the period 1960 to 1965 show gains of approximately 31 percent for the Region while employment in the United States increased by 10 percent. In addition, regional employment growth has been accompanied by changes in the industrial composition of the economy. During the period 1950 to 1965, agriculture and mining remained almost stable as to the number of workers, but declined in relative importance. Employment in manufacturing, the trades and services, and government, on the other hand, increased sharply during this period. This trend toward more diversification stems largely from the Region's attractiveness to light industry; i.e., electronics, precision equipment and the like and the increasing demands of recreation and tourism on the Region.

Per capita personal income in the Region for 1965 amounted to $2,292. This figure, 10 percent below the national average, reflects in part the state of economic depression among the Indian and Mexican-American population of the Region.

Regional Economic Activity

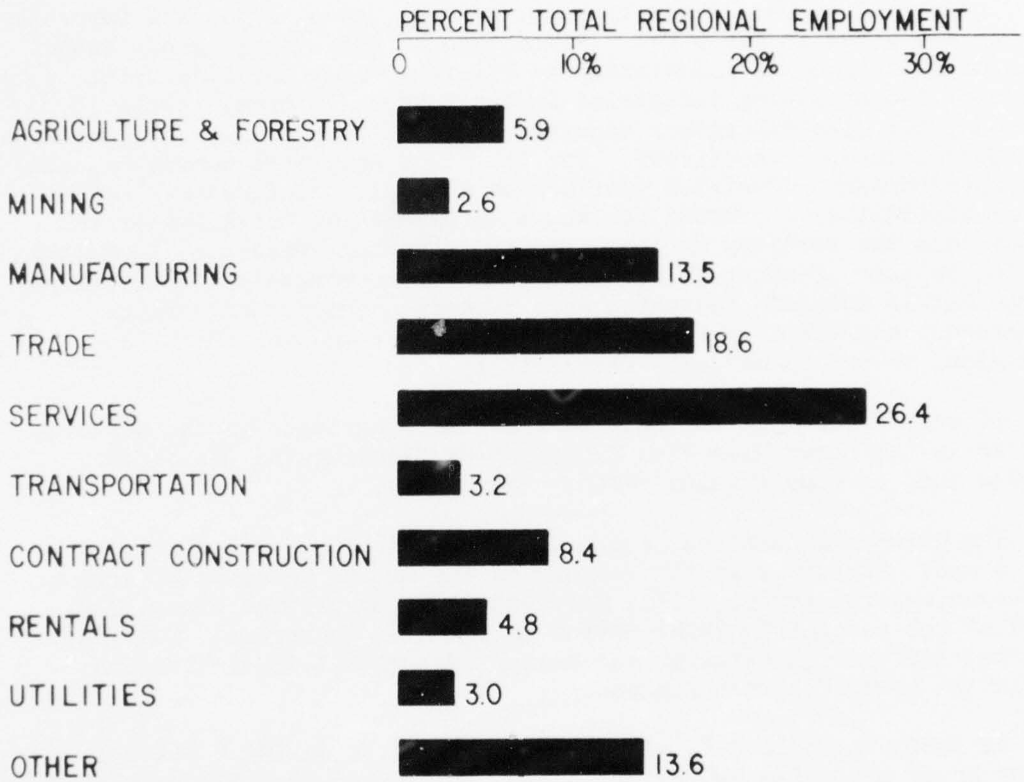
The economic base of the Lower Colorado Region has expanded rapidly during the past decade. Early development, influenced by mining and

Table B-1
Employment by Industries
Lower Colorado Region and United States

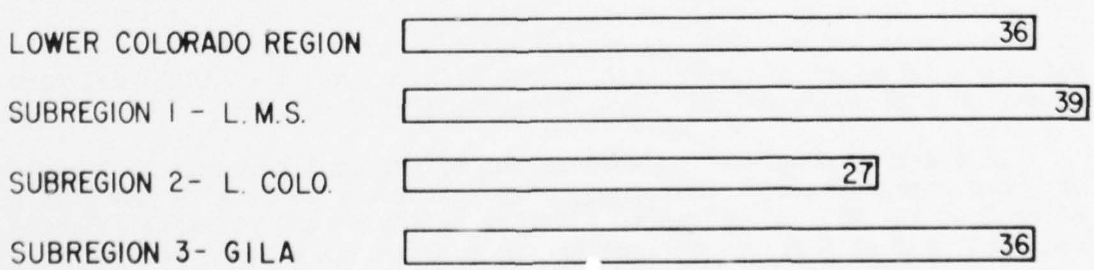
Unit: 1,000

Industry	1950 Region	1950 U.S.A.	1960 Region	1960 U.S.A.	1965 Region	1965 U.S.A.
Agriculture and Forestry	41.8	7,175	39.5	4,470	40.1	4,198
Mining	13.1	945	18.2	675	17.9	589
Manufacturing	24.7	14,801	63.1	18,245	90.9	19,959
Trade	60.7	10,740	104.0	12,288	125.9	13,552
Services	64.8	10,256	135.0	14,124	178.2	17,161
Transportation	15.6	2,997	18.3	2,860	21.5	2,872
Contract Construction	24.3	3,509	48.0	3,968	56.6	4,493
Rentals and Finance	8.0	1,948	24.6	2,821	32.1	3,167
Utilities	9.9	1,516	17.2	1,791	20.4	1,841
Government	25.6	3,588	53.8	5,133	92.1	5,818
Total	288.5	57,475	521.7	66,375	675.7	73,650

FIGURE B-1
EMPLOYMENT BY INDUSTRIES-1965



PERCENT OF TOTAL POPULATION EMPLOYED-1965



agriculture, has expanded to include a variety of manufacturing industries. In addition, recreation and tourism provide a major source of basic income to the economy of the Region.

Industrial output levels by major groups, value added, and imports in 1965 are given in Table B-2. Percentage of subregional gross output by industry in 1965 is illustrated by Figure B-2. Total industrial output of the producing industries in the Lower Main Stem, Little Colorado, and Gila Subregions amounted to about $1.6 million, $.3 million, and $5.7 million, respectively. For the Lower Main Stem Subregion, the primary-secondary industries (defined as agriculture, forestry, mining, and manufacturing) accounted for about 23 percent of total industrial output, and the tertiary or noncommodity producing industries accounted for the balance of about 77 percent. Similar approximate relationships in the Little Colorado Subregion were primary-secondary industries, 60 percent; and tertiary industries, 40 percent; and for the Gila Subregion, 47 and 53 percent, respectively.

Of significance in the base year is the importance of the business sectors in the Lower Main Stem Subregion--reflecting the Las Vegas complex and, to some extent, outdoor recreation.

The primary industries, i.e., mining, forestry, and agriculture, play a more vital role in the economy of the Little Colorado Subregion. The secondary industries, i.e., manufacturing, contribute almost one-third of the total industrial output in the Gila Subregion. Thus, substantial differences exist in the degree of regional specialization within the Lower Colorado Region.

As shown in Table B-2, value added totaled to $1,280.2 million in the Lower Main Stem Subregion; $224.1 million in the Little Colorado Subregion; and $4,524.4 million in the Gila Subregion. On a regional basis, the Gila Subregion accounted for 75 percent of total value added, while the Lower Main Stem and Little Colorado Subregions account for about 21 percent and 4 percent, respectively.

The total value of imports for each subregion is also presented in Table B-2. The Gila Subregion ranks highest, showing $2,257.8 million-worth of goods and services purchased outside the subregion. The Lower Main Stem Subregion followed with $846.4 million, and the Little Colorado Subregion imported goods and services worth $225.7 million.

In order to complete the measurement of regional accounts in terms of broad categories of the economy, it is necessary to measure the flow of product in 1965 as opposed to the flow of income and payments. Gross regional product (GRP) is defined as the sum of four major expenditure components: (1) personal consumption expenditures, (2) government purchases of goods and services, (3) gross private investment, and (4) net export of goods and services. The goods and services included

Table B-2
Total Gross Output by Industry and Associated Total Primary Inputs by Subregion, Lower Colorado Region, 1965

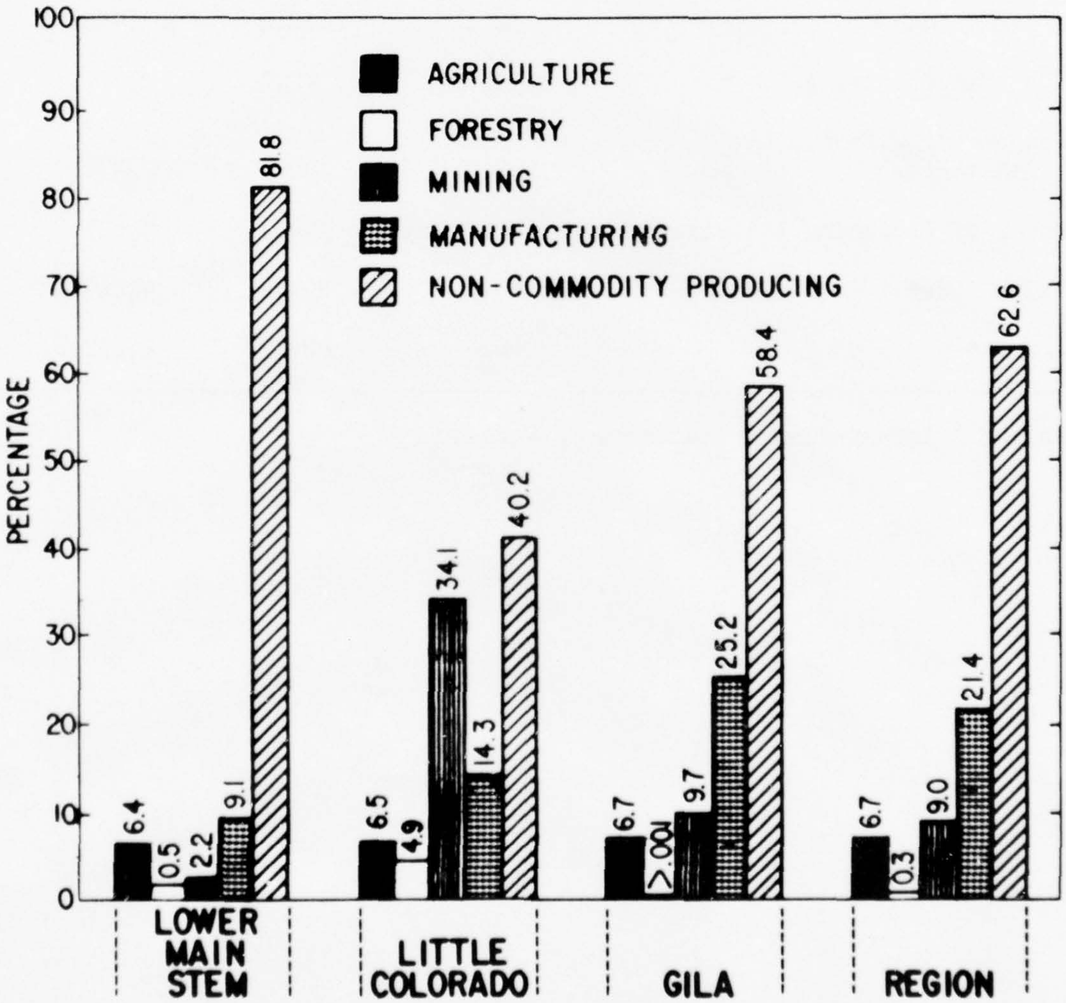
Unit: $ Million

	LMS Subregion	L. Colo. Subregion	Gila Subregion
Producing Industries			
Agriculture	123.3	14.7	458.4
Forestry	5.2	7.3	2.1
Mining	32.1	112.2	458.5
Manufacturing	197.1	72.0	1,759.1
Noncommodity Producing Industries	1,220.5	138.4	2,977.7
Total of Producing Industries	1,578.2	344.7	5,655.8
Value Added	1,280.2	224.1	4,524.4
Imports	846.4	225.7	2,257.8

Source: Interindustry Transactions Table.

FIGURE B-2
PERCENTAGE OF GROSS OUTPUT
BY INDUSTRY-1965

(based on value added)



in GRP are largely associated with market items and every effort is made to measure only the value of final goods and services produced.

Estimated GRP by major components for the Lower Colorado Region for 1965 is shown in Table B-3 and illustrated by Figure B-3. In general, consumer purchases account for the largest share of gross regional product, followed by government expenditures. As indicated in Table B-3, consumer expenditures were roughly triple that of government expenditures in both the Lower Main Stem and Gila Subregions. In the Little Colorado Subregion, government expenditures approximately equal consumer expenditure, due to major Federal and state assistance programs. All subregions imported a larger amount of goods and services than were exported, as indicated by the negative value of net exports.

Table B-3
Gross Regional Product by Subregion,
Lower Colorado Region, 1965

Unit: $ Million

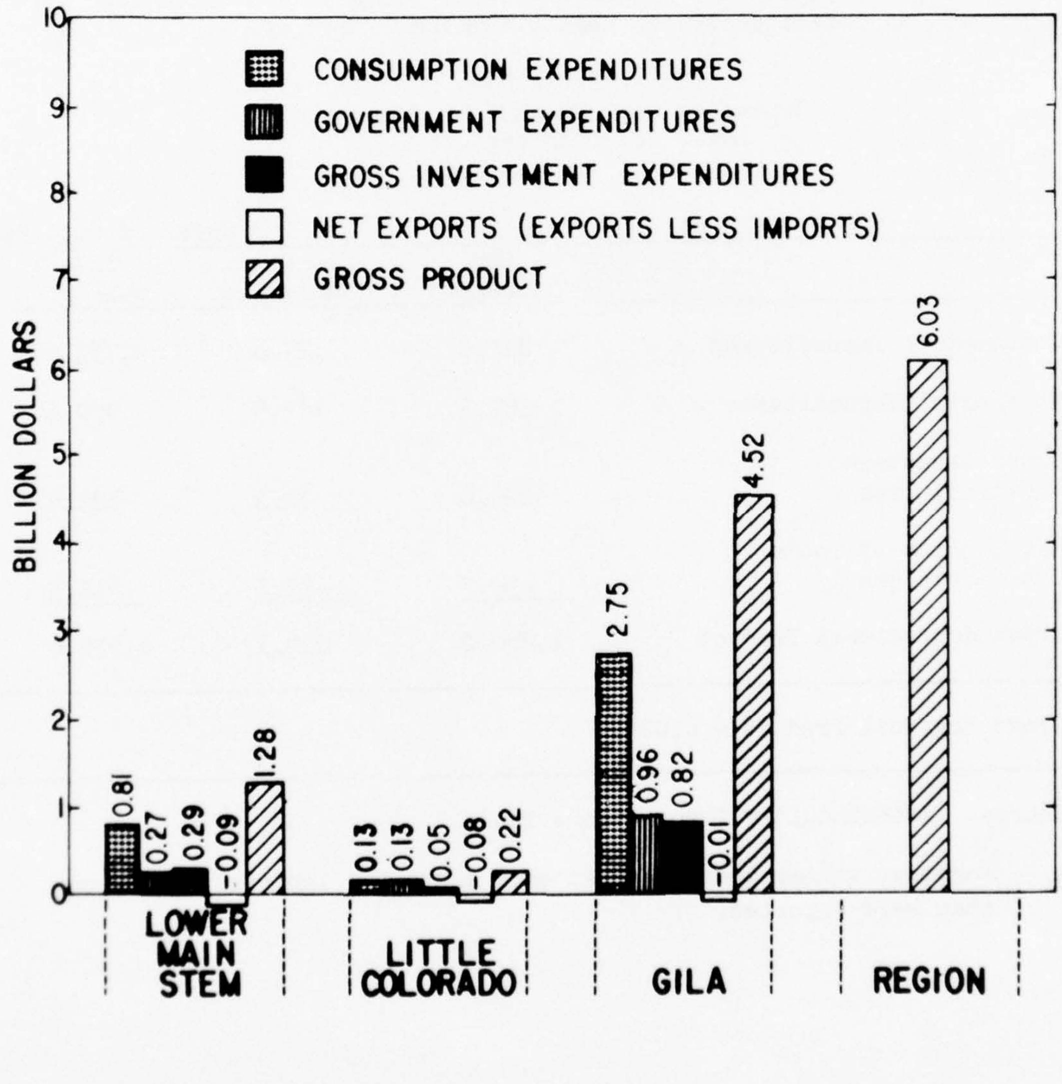
	LMS Subregion	L. Colo. Subregion	Gila Subregion
Consumption Expenditures	811.0	127.8	2,753.6
Government Expenditures	269.3	127.5	959.6
Gross Investment Expenditures	290.6	51.3	822.5
Net Exports of Goods and Services 1/	-90.7	-82.5	-11.3
Gross Subregional Product	1,280.2	224.1	4,524.4

Gross Regional Product = 6,028.7

Source: Interindustry Transactions Table.

1/ Negative values indicate that each subregion imported more goods than were exported.

FIGURE B-3
GROSS REGIONAL PRODUCT-1965



PRESENT WATER USE AND DEVELOPMENT

The principal water control facilities in the Region have been designed to provide for the orderly and efficient use of the Region's water supplies. Spills which are lost to the Region occur infrequently. Unused outflow from the Little Colorado Subregion becomes inflow to the Lower Main Stem for storage and use downstream. Under present conditions, there is essentially no outflow from the Region beyond exports to California and that required to meet the Mexican Treaty obligation.

It should be noted, however, that the historic runoff of the Colorado River during the period 1906-1930, if repeated, could cause large spills to the Gulf of California.

The major utilization of water within the Lower Colorado Region is for agricultural, municipal and industrial purposes. At present, about 94 percent of the total regional water withdrawal from groundwater and surface-water sources is used for irrigated agriculture and 6 percent for municipal, industrial, and other uses. Minor quantities of water are used for cooling in thermal power generation, rural domestic needs, and for livestock. Other minor uses are hydroelectric power, recreation, and fish and wildlife. Municipal and industrial uses are increasing with the Region's growing population.

One of the large consuming uses of water in the Lower Colorado Region is water-surface evaporation. The high rate of evaporation and the essential requirements for storage produce an estimated annual lake evaporation loss of over 1.4 million acre-feet. Almost 85 percent of these losses occur on major reservoirs on the Colorado River. These losses are, in effect, a part of the cost of making possible the orderly use of water for onsite and downstream purposes including the generation of hydroelectric energy, and of considerable importance, of providing recreational opportunities for ever increasing numbers of people.

Table B-4 shows the approximate relationships between amounts of water withdrawn from ground water and surface water in the Region and where this water is used on the basis of estimated 1965 withdrawals. The ratio of depletions to total withdrawals shows a regionwide efficiency of about 62 percent due, in large measure, to the multiple reuse of existing supplies.

As shown in Table B-4, over 60 percent of all withdrawals in the Region come from ground water. Historically, annual ground-water pumpage in the Lower Colorado Region has increased from less than 1 million acre-feet in the early 1930's to 3 million acre-feet following World War II, and to about 5 million acre-feet in 1965.

Table B-4
Estimated Annual Water Withdrawal 1/
1965 Level of Development
Lower Colorado Region

Unit: 1,000 Acre-Feet

Subregion and State	Estimated Annual Water Withdrawal: Ground-Water Pumpage	Surface-Water Diversion	Total Withdrawal
Lower Main Stem			
Arizona	400	1,650	2,050
Nevada	115	155	270
Utah	10	90	100
Total	525	1,895	2,420
Little Colorado			
Arizona	72	57	129
New Mexico	2	21	23
Total	74	78	152
Gila			
Arizona	4,400	1,200	5,600
New Mexico	65	31	96
Total	4,465	1,231	5,696
Lower Colorado Region			
Arizona	4,872	2,907	7,779
New Mexico	67	52	119
Nevada	115	55	170
Utah	10	90	100
Total	5,064	3,204	8,268 2/

1/ Gross: Ground water at pump head, surface water at the source. These values are not necessarily those experienced in 1965, but rather, are the amounts which could be expected to be withdrawn under average conditions with the 1965 level of development.

2/ About 500,000 acre-feet or 6 percent of total estimated withdrawal is used for purposes other than irrigation, and represents an average withdrawal rate of nearly 240 gallons per capita per day.

PRIVATE LINE STUDY

PMS 7012
7/71

SPECIAL INSTRUCTIONS FOR MARKING FORMS

ZERO	0 – O	FIVE	5 – S
LETTER	O – Ø	LETTER	S – S
ONE	1 – I	LETTER	G – G
LETTER	I – I	LETTER	C – C
TWO	2 – Z	LETTER	D – D
LETTER	Z – Ƶ	LETTER	Q – Q

SECTION 2 - EXHIBIT

20

5. SPEED 2

CARD TYPE

T

CARD TYPE

08

A

NOTES:

MULTI-POINT TWPL -
OVER 25 MILES - 100 WPM
DUPLEX - TERM TELCO EQP
TARIFF DESIGNATOR "O"

MILES	AMOUNT	CARD TYPE
1130025047		B
1020023051		B
		B
		B
		B
		B
		B

	CLERICAL	KEY PUNCH
PREPARED BY	LP	
VERIFIED BY	KC	
DATE	8/26/71	

Billing Exchange SAN DIEGO, CALIF

Consolidated Billing No. —

TO BE USED ONLY UPON SPECIAL REQUEST
TYPE L RECORD – MEMORANDUM RECORD OF STATION LOCATION (COLS. 18-80)

O.C.	T.S. CODE	AMOUNT	CARD TYPE	STREET ADDRESS (INCLUDE ROOM OR BUILDING IDENTIFICATION)	CARD TYPE
		0002420	C		L
FB		0013000	C		L
FF		0000300	C		L
		0000050	C		L
		0002420	C		L
FB		0013000	C		L
FF		0000300	C		L
		0000050	C		L
		0002420	C		L
FB		0013000	C		L
FF		0000300	C		L
		0000050	C		L
			C		L

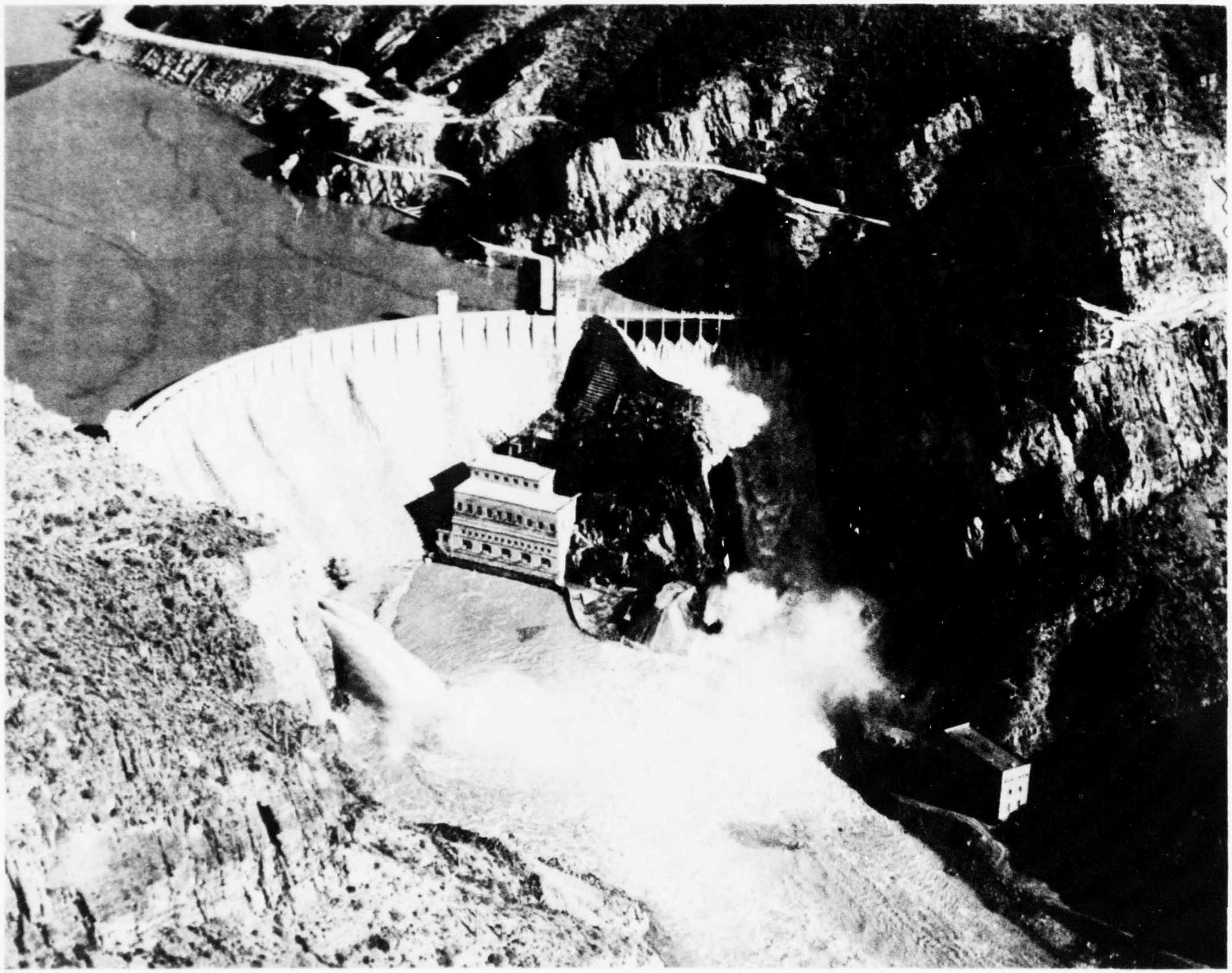
At the present time there is an annual ground-water overdraft of approximately 2.5 million acre-feet, of which about 50,000 acre-feet occur in the Las Vegas area and most of the remainder in central Arizona.

Among the areas of the greatest water demand are the desert lowlands of central Arizona and the Las Vegas Valley in Nevada which must rely substantially on mining of ground-water resources. The results of continued mining of ground water have already been felt in some areas. Lands that were once productive are being retired as wells go dry or as pumping costs rise to a point of no economic gain, or as water quality deteriorates. Until the introduction of other sources of water, or in some cases the economic means to better utilize the present sources, ground-water overdraft will probably continue in order to meet the demands for water.

Table B-5 is the summary of estimated depletions and withdrawal requirements, respectively, for the various water-oriented activities in the Lower Colorado Region at the 1965 level of development. Note that the estimated 1965 withdrawal requirements excluding evaporation for the Region is about 1.5 million acre-feet more than the actual amount being withdrawn as indicated by records. The difference reflects the effects of all restraints under the present conditions of water supply. Restraints include water supply deficiencies, economics, water rights, water quality, etc., and all of their ramifications.

There are presently 15 significant manmade impoundments on the Colorado River and its tributaries within the Lower Colorado Region. Seven of these are on the Colorado and eight are on tributaries. Aggregate usable capacities are 28.6 million acre-feet and 3.2 million acre-feet for the Colorado and tributaries, respectively. Largest of all manmade impoundments in the Region as well as in the Nation is Lake Mead with a usable storage capacity of 26.2 million acre-feet.

Hoover Dam and Lake Mead exemplify the concept of multipurpose use of stored water including: flood control; power generation; irrigation; recreation; fish and wildlife and other uses.



Theodore Roosevelt Dam, completed in 1911 on the Salt River in Arizona, is the forerunner of multipurpose water storage projects in the Region and still provides flood control, water for irrigation, municipal and industrial uses, hydroelectric power generation, and recreation.

Table B-5
Lower Colorado Region
Estimated Water Requirements
1965 Level of Development
Hydrologic Areas

Unit: 1,000 Acre-Feet

Uses	Withdrawal Requirements				Depletion Requirements			
	Subregions				Subregions			
	1	2	3	Region	1	2	3	Region
Reservoir Evaporation 1/	32.3	39.4	158.7	230.4	32.3	39.4	158.7	230.4
Mineral Resources	6.4	1.0	97.7	105.1	2.6	0.6	48.3	51.5
Irrigation	2,682.4	136.2	6,319.8	9,138.4	1,107.1	58.6	4,059.8 2/	5,225.5
Municipal and Industrial	115.6	19.5	315.1	450.2	48.2	8.8	140.9	197.9
Recreation	3.2	1.5	5.9	10.6	1.1	0.5	2.0	3.6 3/
Fish and Wildlife	140.0	6.0	50.0	196.0	100.0	4.3	6.0	110.3
Electric Power	2.8	0.8	6.0	9.6	2.8	0.8	6.0	9.6
Total	2,982.7	204.4 4/	6,953.2	10,140.3	1,294.1	113.0 4/	4,421.7	5,828.8

1/ Exclusive of Colorado River mainstream evaporation and sewage losses which are accounted for in the determination of available Colorado River water.

2/ Includes noncrop consumption associated with irrigation estimated as 15 percent of the computed irrigation requirement. Also includes an estimated 600,000 acre-feet per year of water losses in-transit in the central Arizona area of Subregion 3.

3/ Represents requirements exclusive of existing lake and reservoir evaporation.

4/ Excludes normal annual export of 15,000 acre-feet to the Gila Subregion.

WATER QUALITY

Regionally, mineral water quality as expressed by total dissolved solids (TDS) concentrations is generally of lower quality than in many other parts of the Nation. Many surface- and ground-water supplies of the Region have mineral concentrations exceeding 500 milligrams per liter, and many exceed 1,000 mg/l.

The Colorado River, one of the two major supplies, enters the Region at concentrations exceeding 500 mg/l and varies between 600 and 900 mg/l at major diversion points within the Region. Long-term data indicate that some 8.8 million tons of dissolved solids are transported annually into the Region from the Upper Colorado Region.

Salinity increases in the Lower Colorado River as it proceeds downstream are due principally to inputs from saline springs and the concentrating effects of consumptive use and surface evaporation from reservoir and river water surfaces. With average evaporations approaching 84 inches annually, the reservoir losses in the reach from Lake Mead to Imperial Dam exceed one million acre-feet per year. In addition, river losses in this reach including evaporation, transpiration, and seepage, are about 0.66 million acre-feet annually.

Significant increases in dissolved solids from headwaters to mouth occur similarly in the Gila River. In the headwaters of the Gila, TDS concentrations are generally less than 500 mg/l. However, in the middle reaches below points of major diversions, the dissolved salt content usually ranges from about 500 to 1,000 mg/l. Most of the increase in dissolved solids concentrations results from the concentrating effects of consumptive uses and from salts contributed directly by the soil to irrigation water. Below Gillespie Dam near Phoenix, all of the highly mineralized (mean TDS 3,000 mg/l) return flows from the Phoenix-Buckeye area are diverted at Gillespie Dam for irrigation use.

Water quality is generally good in most of the headwaters of the Little Colorado River. The middle reaches of the Little Colorado River flow only intermittently. At the confluence with the Colorado River, flows contain very high concentrations of dissolved solids from saline springs located near the mouth of the Little Colorado River. A map following page XVIII-34 shows the location of salt springs.

Some surface waters in the Region are very hard and at best are only marginally suitable for domestic uses. The Colorado River has a hardness (as calcium carbonate) varying from about 330 mg/l at Lee Ferry, Arizona, to about 370 mg/l at Imperial Dam. Downstream at Yuma, Arizona, the hardness increases to 700 mg/l.

PRESENT STATUS

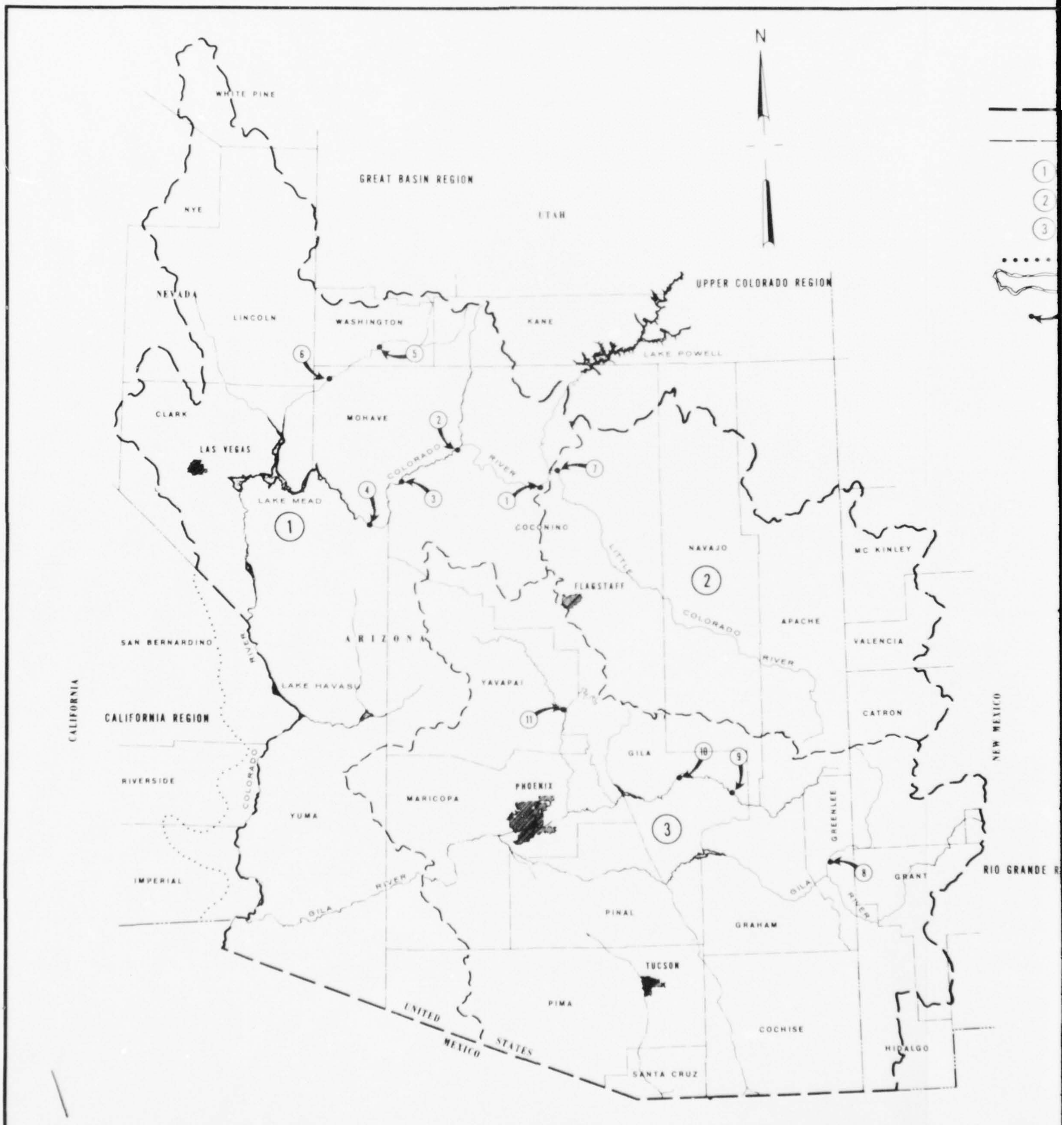
Although fluoride content ranges from a trace to about 4 or 5 mg/l, it is normally about 1 mg/l or less in most water of the Region. This relatively high level of natural fluoride concentration persists even during flooding on some upstream portions of the Gila River. A few isolated sample points show fluoride contents of more than 10 mg/l.

Sediment concentrations in surface water of the Region range from very high to moderate. The areas of greatest sediment yield are located in northwestern Arizona and southwestern Utah where sediment concentrations as great as 700,000 parts per million have been measured and 500,000 ppm observations are not unusual. On Basin and Range Lowlands, the yields are moderate with concentrations in the adjacent streams averaging about 20,000 ppm. Annual average sediment yield in most areas remains within moderate bounds due to infrequent occurrence of heavy rainfall. The major mainstream Colorado River reservoirs serve as sediment traps. Most of the sediment picked up between Parker and Imperial Dams is removed by the All-American Canal Desilting Works and deposited in the area between Imperial and Laguna Dams. About 500,000 tons annually are removed.

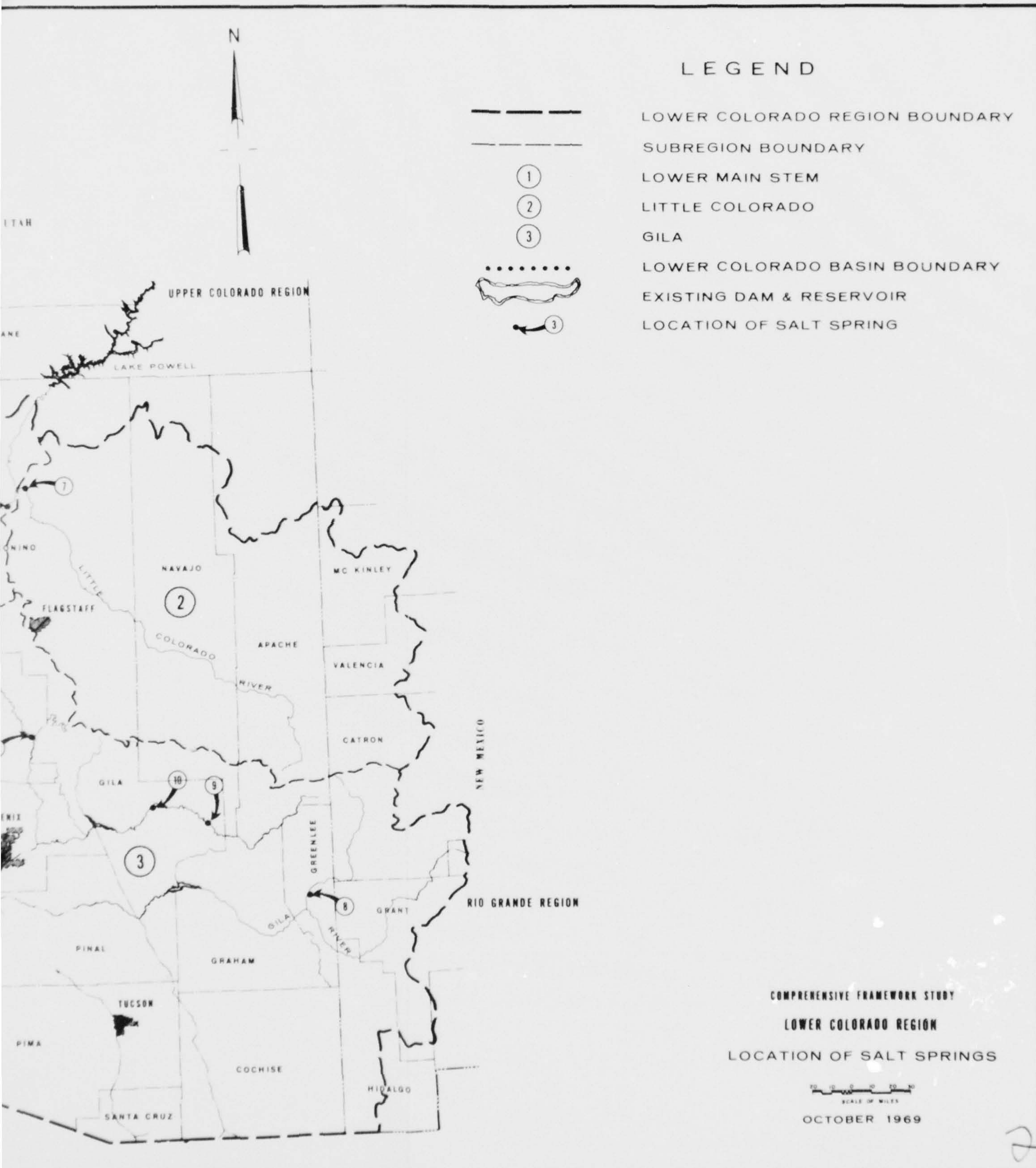
The presence of nutrients from manmade sources has caused excessive algal growths in Las Vegas Bay of Lake Mead, a major recreational area. In isolated cases, bacterial concentrations have exceeded desirable levels in streams below smaller communities and resource areas. Occasional overflows and breaks in mining waste disposal systems in the Gila Subregion have resulted in fish kills due to the toxic wastes.

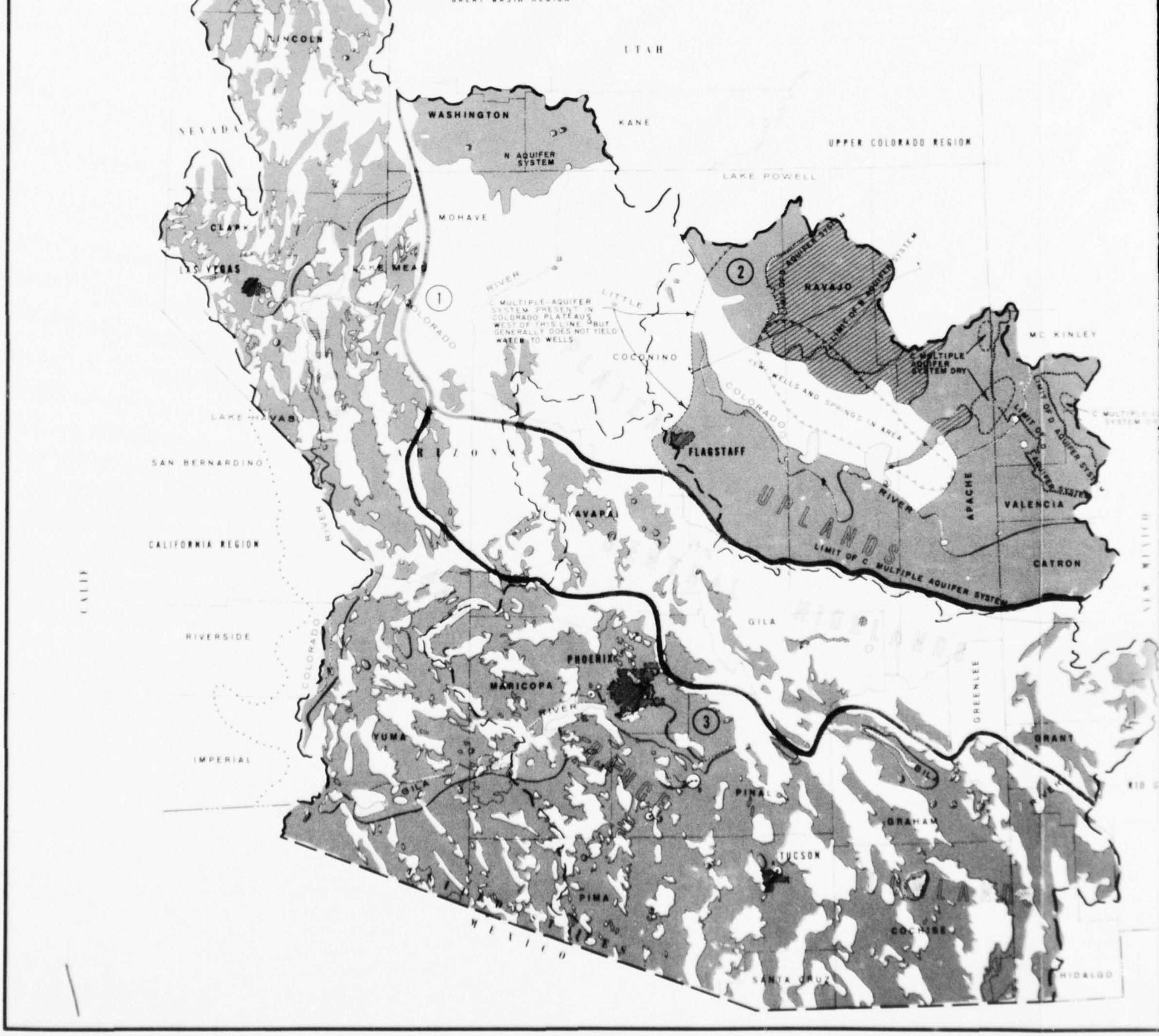
The mineral quality of ground water ranges from excellent to unsuitable for any purpose. Ground water in the alluvial deposits of the Basin and Range Lowlands, for example, contains from less than 100 to more than 100,000 mg/l of dissolved solids. Water from most of these deposits, however, contains dissolved solids concentrations of less than 1,000 mg/l. Concentrations of total dissolved solids in ground water from aquifers beneath lowlands often vary, not only areally, but also with depth. As a result, the concentrations of dissolved solids in water from a given well may change abruptly with the amount of drawdown as will the ionic makeup. In contrast, major sandstone aquifers in the Plateau Uplands of northern Arizona contain water having consistently more than 10,000 mg/l dissolved solids. In the same overall area, the dissolved solids concentrations ranged from 90 to more than 60,000 mg/l for 1,500 samples analyzed. A map following this page indicates the location and extent of dissolved solids in ground water.

The ground water ranges from soft to very hard, from less than 60 mg/l to more than 180 mg/l of calcium carbonate. The concentrations of the minor constituents such as iron, magnesium, and silica vary considerably throughout the Region; but, except for fluoride and nitrate, the concentrations are not objectionable for most uses. Though concentrations of nitrate are generally small in water from drilled wells,



N
GREAT BASIN REGION
UTAH
UPPER COLORADO REGION
WHITE PINE
NYE
NEVADA
LINCOLN
WASHINGTON
KANE
LAKE POWELL
CLARK
LAS VEGAS
MOHAVE
COLORADO
RIVER
LAKE MEAD
COCONINO
NAVAJO
MC KINLEY
LITTLE COLORADO RIVER
FLAGSTAFF
APACHE
VALENCIA
SAN BERNARDINO
ARIZONA
LAKE HAVASU
YAVAPAI
CATRON
CALIFORNIA
CALIFORNIA REGION
GILA
NEW MEXICO
RIVERSIDE
MARICOPA
PHOENIX
GREENLEE
YUMA
GRANT
RIO GRANDE R
IMPERIAL
GILA RIVER
PINAL
GRAHAM
TUCSON
PIMA
COCHISE
UNITED STATES
MEXICO
HIDALGO
SANTA CRUZ


N
LEGEND
LOWER COLORADO REGION BOUNDARY
SUBREGION BOUNDARY
1 LOWER MAIN STEM
2 LITTLE COLORADO
3 GILA
LOWER COLORADO BASIN BOUNDARY
EXISTING DAM & RESERVOIR
LOCATION OF SALT SPRING
UTAH
UPPER COLORADO REGION
LAKE POWELL
NAVAJO
MC KINLEY
FLAGSTAFF
LITTLE COLORADO RIVER
APACHE
VALENCIA
CATRON
NEW MEXICO
GILA
GREENLEE
GRANT
RIO GRANDE REGION
GILA RIVER
PINAL
GRAHAM
TUCSON
PIMA
COCHISE
HIDALGO
SANTA CRUZ
COMPREHENSIVE FRAMEWORK STUDY
LOWER COLORADO REGION
LOCATION OF SALT SPRINGS
OCTOBER 1969


WHITE PINE
NYE
GREAT BASIN REGION
LINCOLN
UTAH
NEVADA
WASHINGTON
N AQUIFER SYSTEM
KANE
UPPER COLORADO REGION
LAKE POWELL
CLARK
MOHAVE
LAS VEGAS
LAKE MEAD
1
2
NAVAJO
RIVER
COLORADO
LITTLE
C MULTIPLE-AQUIFER SYSTEM PRESENT IN COLORADO PLATEAUS WEST OF THIS LINE, BUT GENERALLY DOES NOT YIELD WATER TO WELLS
MC KINLEY
COCONINO
C MULTIPLE AQUIFER SYSTEM DRY
FEW WELLS AND SPRINGS IN AREA
LAKE HAVASU
ARIZONA
FLAGSTAFF
SAN BERNARDINO
UPLANDS
APACHE
VALENCIA
YAVAPAI
CALIFORNIA REGION
LIMIT OF C MULTIPLE AQUIFER SYSTEM
CATRON
GILA
RIVERSIDE
PHOENIX
MARICOPA
GREENLEE
3
YUMA
GRANT
IMPERIAL
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TUCSON
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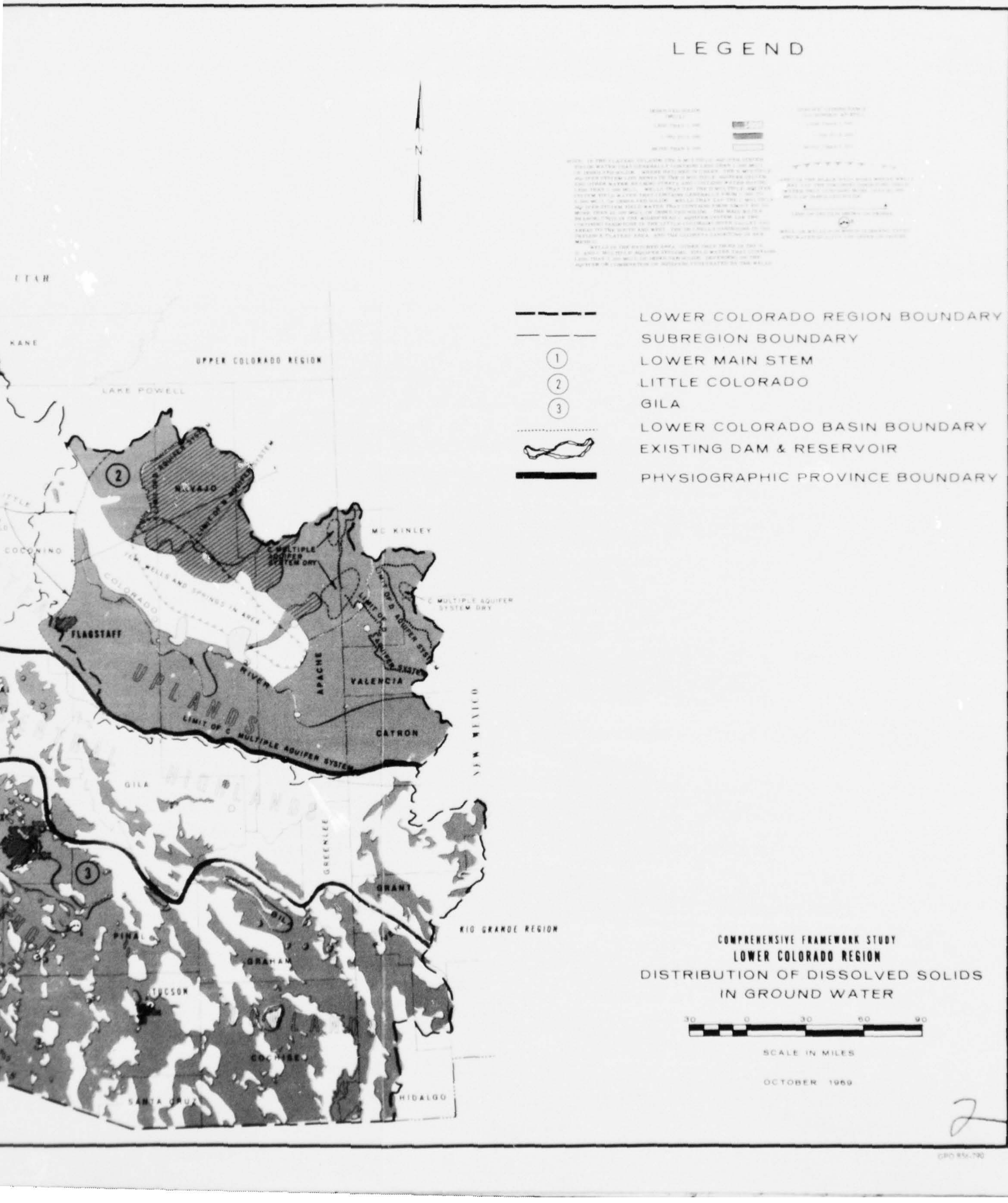
LEGEND
LOWER COLORADO REGION BOUNDARY
SUBREGION BOUNDARY
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2 LITTLE COLORADO
3 GILA
LOWER COLORADO BASIN BOUNDARY
EXISTING DAM & RESERVOIR
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LIMIT OF C MULTIPLE AQUIFER SYSTEM
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GRANT
PINAL
GRAHAM
TUCSON
COCHISE
SANTA CRUZ
HIDALGO
RIO GRANDE REGION
COMPREHENSIVE FRAMEWORK STUDY
LOWER COLORADO REGION
DISTRIBUTION OF DISSOLVED SOLIDS
IN GROUND WATER
30 0 30 60 90
SCALE IN MILES
OCTOBER 1969

in northern Arizona water from dug wells may contain more than 45 mg/l of nitrate which is the maximum concentration recommended in the United States Public Health Service Drinking Water Standards. More than 4 mg/l of fluoride is common in ground waters of northern Arizona. Water from many wells in the Basin and Range Lowlands will contain more than 2 mg/l of fluoride. Fluoride concentrations in excess of the upper limits recommended by the USPHS Drinking Water Standards, are found in ground waters throughout the Lower Colorado Region.

Boron concentrations of 0.4 mg/l, the critical level for citrus crops, have been observed in Colorado River water at Imperial Dam.

Other conditions presently affecting water quality and public health in the Lower Colorado Region are as follows:

1. The presence of potentially water-borne disease in the Region;

2. Open surface-water conveyance systems presenting the possibility of contamination by radiological means, or by accidental spills of toxic materials;

3. Bacteriological quality of water supplies at some recreational areas which do not conform with United States Public Health Service Drinking Water Standards, 1962;

4. Thermal pollution resulting from irrigation return flows, municipal and industrial wastes;

5. Contamination of streams by runoff from livestock wastes and other solid wastes;

6. Lack of water to maintain minimum streamflows; and

7. Lack of an effective disease vector control program.

LAND RESOURCES AND USE

Land Ownership and Administration

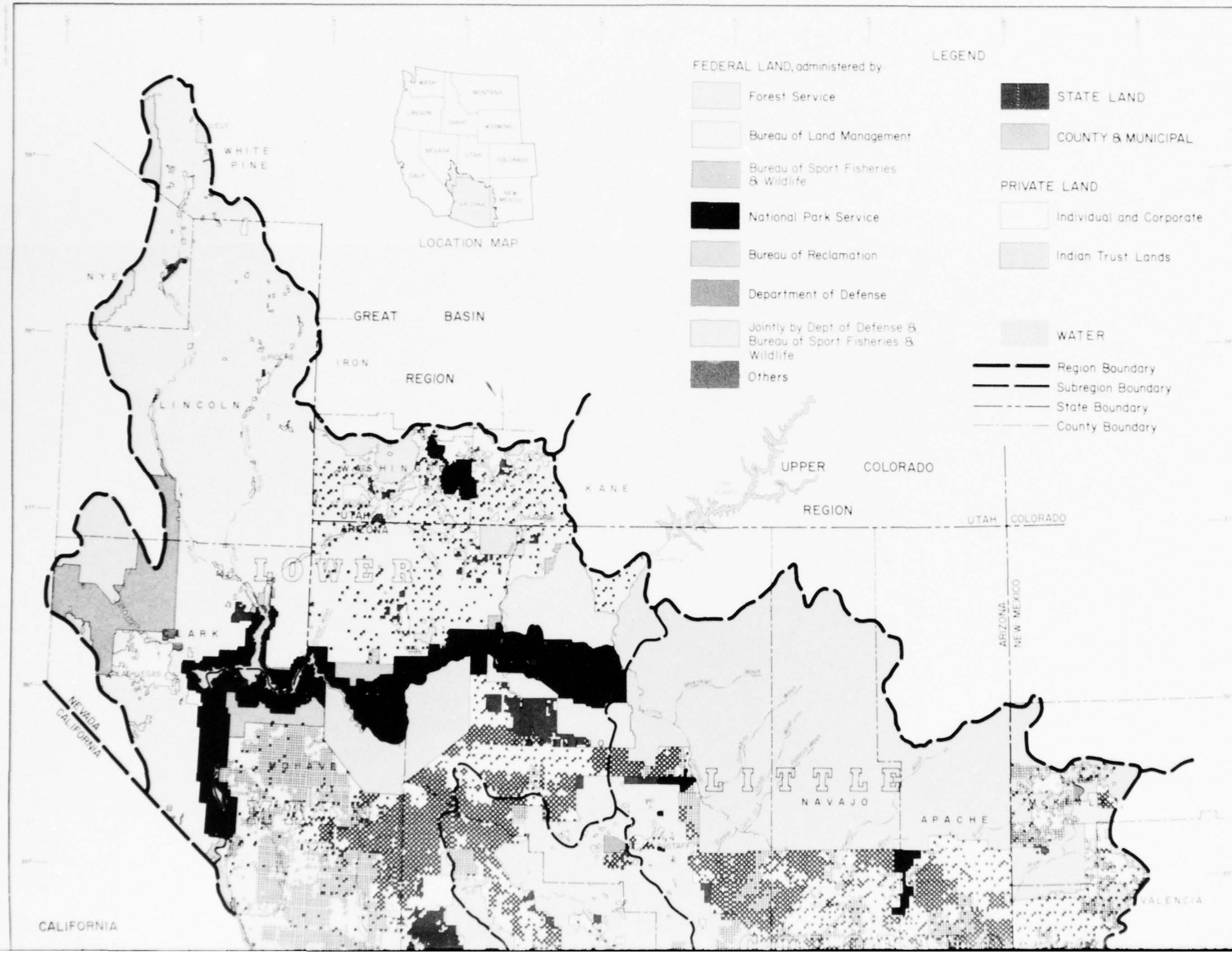
In 1965 about 18 percent of the total land within the Lower Colorado Region was in private ownership, 18 percent in Indian Trust, 12 percent in state and municipal ownership, and the remaining 52 percent was in Federal ownership. Of the land in Federal ownership, 59 percent was administered by the Department of the Interior, 32 percent by the Department of Agriculture, and 9 percent was administered by the Department of Defense. The basic land ownership and administration statistics (for each subregion and the regional total) are presented in Tables B-6, B-7, B-8, and B-9, and illustrated by Figure B-6 and the map following page XVIII-36 shows the location of lands under the various administrative agencies.

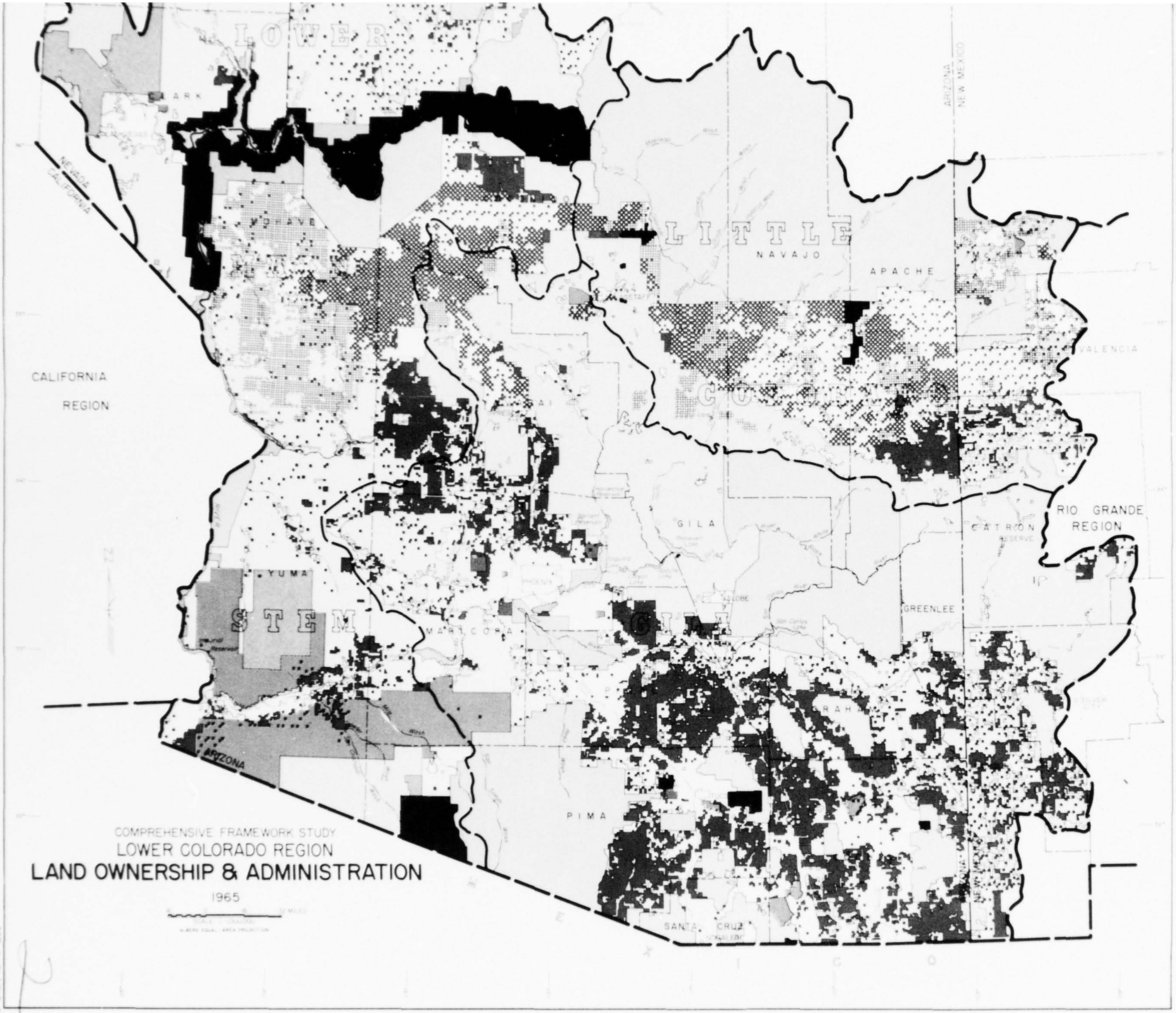
Soils

The soils of the Lower Colorado Region are inherent to the parent materials of the two broad physiographic provinces; the Colorado Plateau Province that occupies the northeast part, and generally the high elevations of the Region; and the Basin and Range Province that encompasses the remainder of the Region. The parent materials from which the soil bodies have developed range from Precambrian basement rocks, comprising granites and metamorphics; to relatively young volcanic materials, with sedimentary material of sandstones, limestones, and shales contributing to the soil characteristics throughout much of the Region.

In the Colorado Plateau Province the major parent materials are older marine and continental sedimentary rocks that range from limestone to sandstone and shales. Local soils in places have developed from volcanic rocks that have intruded these sedimentaries. In the Basin and Range Province the soils have usually developed on alluvial materials derived from the igneous and sedimentary rocks that comprise the mountain ranges typical of the Province.

Soils of the Colorado Plateau Province--This Province comprises the entire Little Colorado Subregion and a portion of both the Gila and Lower Main Stem Subregions. In general, the soils in this Province are shallow in depth to the parent material, often quite erodible,and severely dissected in places. Most of the soils on the Plateau are on gentle slopes except those in the mountains. The soils in the mountains on steep to very steep slopes are shallow to very shallow. Most of the soils in this Province have textures favorable to the entrance and movement of water, except where developed from clayey materials.


LEGEND
FEDERAL LAND, administered by
Forest Service
Bureau of Land Management
Bureau of Sport Fisheries & Wildlife
National Park Service
Bureau of Reclamation
Department of Defense
Jointly by Dept of Defense & Bureau of Sport Fisheries & Wildlife
Others
STATE LAND
COUNTY & MUNICIPAL
PRIVATE LAND
Individual and Corporate
Indian Trust Lands
WATER
Region Boundary
Subregion Boundary
State Boundary
County Boundary
LOCATION MAP
GREAT BASIN REGION
UPPER COLORADO REGION
LOWER
LITTLE
WHITE PINE
NYE
LINCOLN
IRON
KANE
WASHINGTON
UTAH
ARIZONA
CLARK
MOHAVE
NAVAJO
APACHE
McKINLEY
VALENCIA
UTAH COLORADO
ARIZONA NEW MEXICO
NEVADA CALIFORNIA
CALIFORNIA



LOWER
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GRAHAM
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SANTA CRUZ
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NEVADA
CALIFORNIA
ARIZONA
ARIZONA
NEW MEXICO
CALIFORNIA REGION
RIO GRANDE REGION
RIVER
COMPREHENSIVE FRAMEWORK STUDY
LOWER COLORADO REGION
LAND OWNERSHIP & ADMINISTRATION
1965

M7-S-21431A-N

Table B-6
Land Ownership and Administration - 1965
Lower Main Stem Subregion

Unit: 1,000 Acres

Land Ownership and Administration	Area: State of Arizona	State of Nevada	State of Utah	Total
Federal Lands				
Department of Agriculture				
Forest Service	1,432	336	289	2,057
Department of the Interior				
Bureau of Land Management	7,526	8,123	1,115	16,764
Bureau of Sport Fisheries & Wildlife	772	932	0	1,704
National Park Service	2,091	441	139	2,671
Other (Bureau of Reclamation)	364	54	0	418
Department of Defense	3,109 1/	526 2/	0	3,635
Other	0	14 3/	0	14
Subtotal Federal Lands	(15,294)	(10,426)	(1,543)	(27,263)
State-owned Lands	2,280	39	137	2,456
Other Public Lands	3	0	0	3
Subtotal Non-Federal Public Lands	(2,283)	(39)	(137)	(2,459)
Privately owned Lands				
Individual or Corporate	3,368	473	554	4,395
Indian Trust Lands 4/	1,824	5	0	1,829
Subtotal Private Lands	(5,192)	(478)	(554)	(6,224)
Total	22,769	10,943	2,234	35,946

1/ Includes Cabeza Prieta Game Refuge which is administered jointly with the Bureau of Sport Fisheries and Wildlife.

2/ This includes Desert Game Refuge administered jointly with the Bureau of Sport Fisheries and Wildlife.

3/ Administered by County, State, etc.

4/ All Bureau of Indian Affairs administered lands appear as line item "Indian Trust."

Table B-7
Land Ownership and Administration - 1965
Little Colorado Subregion

Unit: 1,000 Acres

Land Ownership Administration	Area: State of Arizona	State of New Mexico	Total
Federal Lands			
Department of Agriculture			
Forest Service	1,990	332	2,322
Department of the Interior			
Bureau of Land Management	313	548	861
Bureau of Sport Fisheries & Wildlife	0	0	0
National Park Service	159	0	159
Other (Bureau of Reclamation)	0	0	0
Department of Defense	0	13	13
Other	0	0	0
Subtotal Federal Lands	(2,462)	(893)	(3,355)
State-owned Lands	1,354	326	1,680
Other Public Lands	0	0	0
Subtotal Non-Federal Public Lands	(1,354)	(326)	(1,680)
Privately owned Lands			
Individual or Corporate	2,989	1,088	4,077
Indian Trust Lands 1/	7,052	1,088	8,140
Subtotal Private Lands	(10,041)	(2,176)	(12,217)
Total	13,857	3,395	17,252

1/ Includes Bureau of Indian Affairs administered lands.

Table B-8
Land Ownership and Administration - 1965
Gila Subregion

Unit: 1,000 Acres

Land Ownership and Administration	Area: State of Arizona	State of New Mexico	Total
Federal Lands			
Department of Agriculture			
Forest Service	8,103	2,493	10,596
Department of the Interior			
Bureau of Land Management	4,104	958	5,062
Bureau of Sport Fisheries & Wildlife	0	0	0
National Park Service	94	0	94
Other (Bureau of Reclamation)	0	0	0
Department of Defense	435	0	435
Other	86	0	86
Subtotal Federal Lands	(12,822)	(3,451)	(16,273)
State-owned Lands	5,674	766	6,440
Other Public Lands	22	0	22
Subtotal Non-Federal Public Lands	(5,696)	(766)	(6,462)
Privately owned Lands			
Individual or Corporate	6,680	932	7,612
Indian Trust Lands 1/	6,443	0	6,443
Subtotal Private Lands	(13,123)	(932)	(14,055)
Total	31,641	5,149	36,790

1/ Includes Bureau of Indian Affairs administered lands.

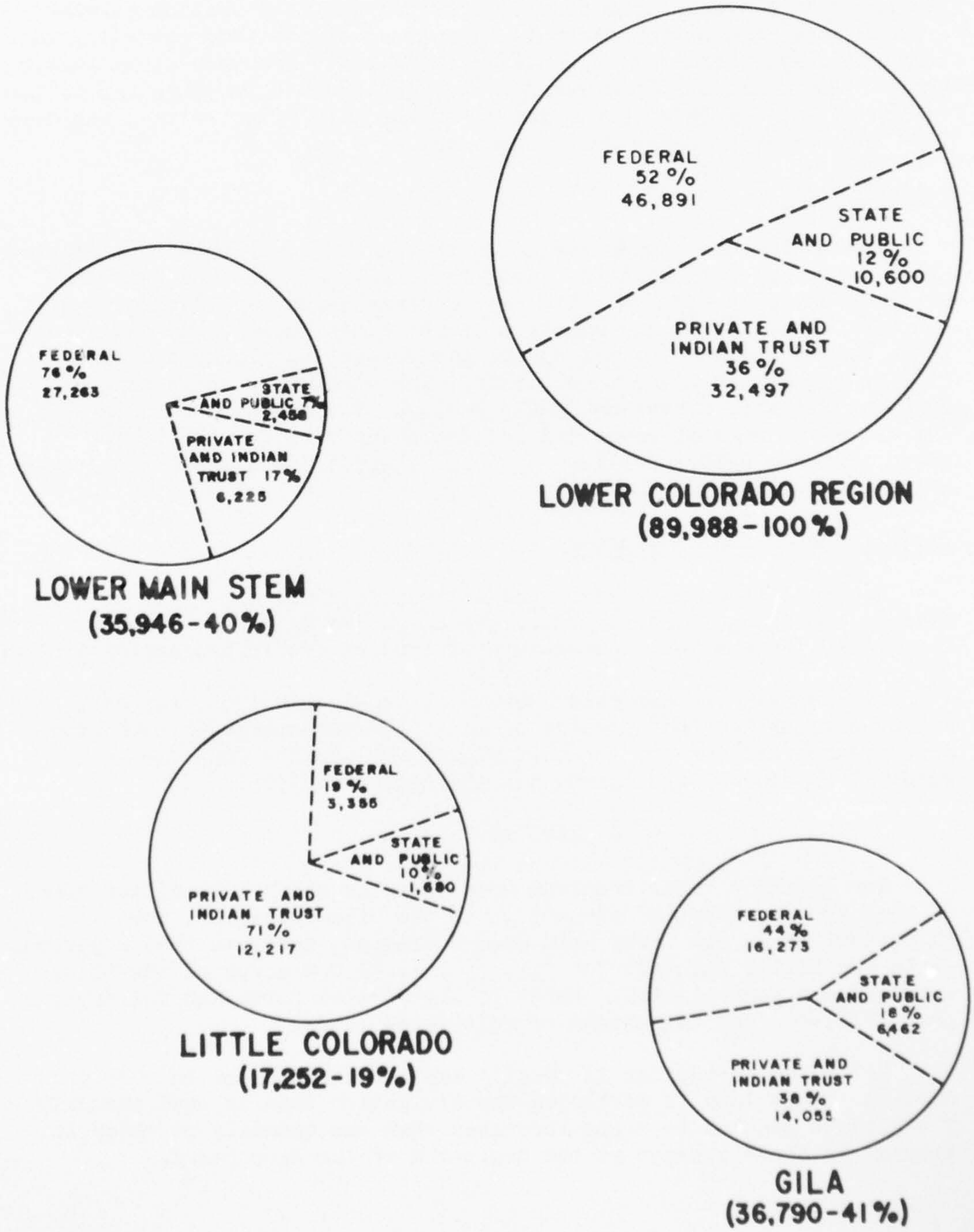
Table B-9, Land Ownership and Administration - 1965
Lower Colorado Region Summary

Unit: 1,000 Acres

Land Ownership and Administration	State of Arizona	State of Nevada	State of Utah	State of New Mexico	Total
Federal Lands					
Department of Agriculture					
Forest Service	11,525	336	289	2,825	14,975
Department of the Interior					
Bureau of Land Management	11,943	8,123	1,115	1,506	22,687
Bureau of Sport Fisheries & Wildlife	772	932	0	0	1,704
National Park Service	2,344	441	139	0	2,924
Other (Bureau of Reclamation)	364	54	0	0	418
Department of Defense	3,544	526	0	13	4,083
Other	86	14	0	0	100
Subtotal Federal Lands	(30,578)	(10,426)	(1,543)	(4,344)	(46,891)
State-owned Lands	9,308	39	137	1,092	10,576
Other Public Lands	25	0	0	0	25
Subtotal Non-Federal Public Lands	(9,333)	(39)	(137)	(1,092)	(10,601)
Privately owned Lands					
Individual or Corporate	13,037	473	554	2,020	16,084
Indian Trust Lands	15,319	5	0	1,088	16,412
Subtotal Private Lands	(28,356)	(478)	(554)	(3,108)	(32,496)
Total	68,267	10,943	2,234	8,544	89,988

Note: Only land areas, water areas are not included.

FIGURE B-6
LAND OWNERSHIP-1965



PRESENT STATUS

Soils of the Basin and Range Province--This Province is characterized by steep, generally barren, northwest-southeast trending mountains and broad alluvial-fill valleys. Most of the soils in the basins and valleys of this Province are deep, level to nearly level, and have textures favorable to both water entrance and soil workability. The soils on the mountains of this Province are very shallow to moderately deep, and are on steep to very steep slopes, and generally have loamy to clayey textures. In places these soils are very stony and/or rocky. Important source areas for sediment in this Province are in the valley of the San Pedro River and along the Gila River between San Carlos Lake and the Arizona-New Mexico boundary.

Vegetal Cover

The Region has a wide variation in vegetal cover types and related categories that determine the resources, uses, and developments that exist or may be projected. The natural vegetation ranges from desert through the chaparral and mountain brush, pinon-juniper and oak woodland, to the yellow pine and spruce-fir forest, to alpine and tundra type on top of the highest mountains. The vegetal cover is dependent upon the climate, elevation, soil, geologic formation, and topography. The extent of vegetal cover and related categories for the Region is shown in Table B-10 and illustrated by Figure B-7 and the Vegetal Cover Map following page XVIII-42

Present Use of Land Resources

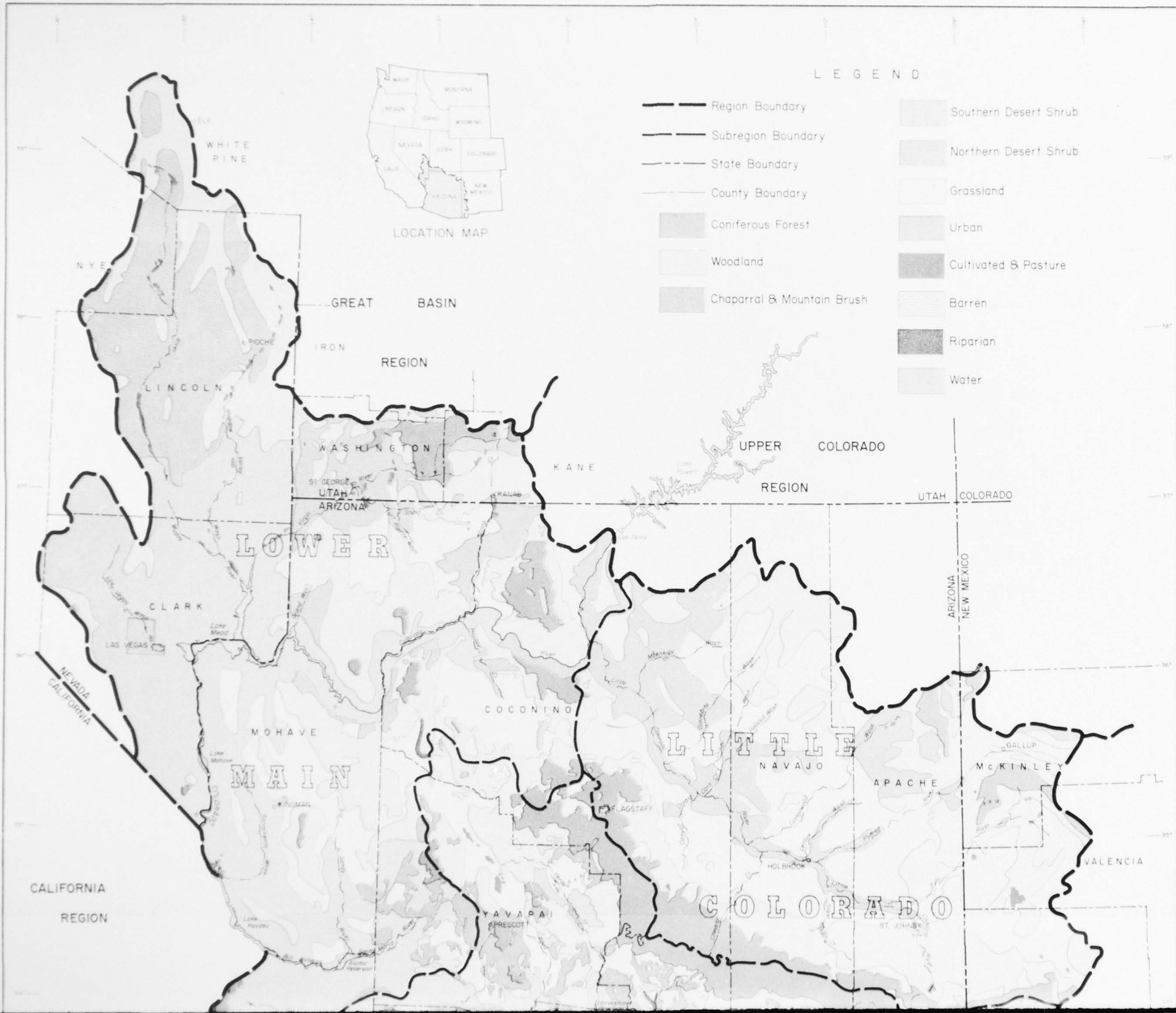
Numerous resources, uses, and activities presently exist on all classes of regional lands. These are as varied as is the climate, topography, vegetation, and pattern of land ownership and administration.

Tables B-11 through B-14 show total acreage in 1965, for each land resource group and the acreages of multiple-use demands in each group, by subregion and for the Region. Figure B-8 depicts land use by resource groups for subregions and the Region in 1965.

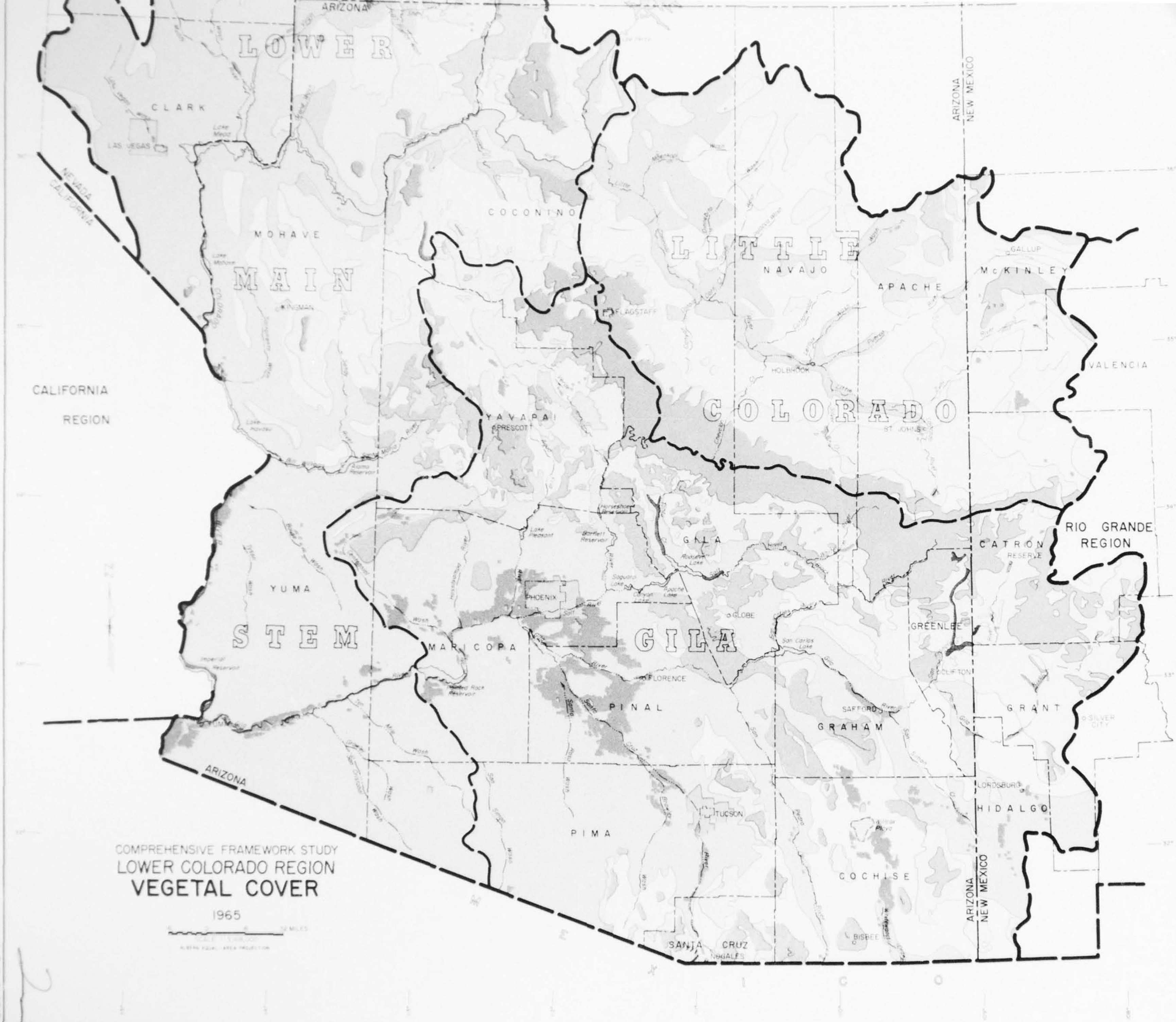
Cultivated Cropland

The Region's total cropland area contains about 1.8 million acres. Of this amount, about 77 percent is in the Gila Subregion, some 21 percent is in the Lower Main Stem Subregion, and less than 2 percent is in the Little Colorado Subregion. Only 31,000 acres of the total cropland are nonirrigated. Refer to the Vegetal Cover Map following page XVIII-42 for the extent of cultivated lands.

Water for irrigation is usually the limiting factor in crop production. More land is developed for irrigation than is used annually. The acreage planted to crops increases when the quantity of water in storage is above average at the beginning of the crop years.



LEGEND
Region Boundary
Subregion Boundary
State Boundary
County Boundary
Coniferous Forest
Woodland
Chaparral & Mountain Brush
Southern Desert Shrub
Northern Desert Shrub
Grassland
Urban
Cultivated & Pasture
Barren
Riparian
Water
LOCATION MAP
GREAT BASIN REGION
UPPER COLORADO REGION
CALIFORNIA REGION
LOWER
MAIN
LITTLE
COLORADO
WHITE PINE
NYE
LINCOLN
PIOCHE
IRON
WASHINGTON
ST. GEORGE
UTAH
ARIZONA
KANE
KANAB
CLARK
LAS VEGAS
NEVADA
CALIFORNIA
MOHAVE
KINGMAN
COCONINO
FLAGSTAFF
YAVAPAI
PRESCOTT
NAVAJO
HOLBROOK
APACHE
ST. JOHNS
McKINLEY
GALLUP
VALENCIA
UTAH COLORADO
ARIZONA NEW MEXICO



LOWER
MAIN
STEM
LITTLE
COLORADO
GILA
CLARK
LAS VEGAS
NEVADA
CALIFORNIA
ARIZONA
MOHAVE
KINGMAN
COCONINO
FLAGSTAFF
NAVAJO
HOLBROOK
APACHE
ST. JOHNS
McKINLEY
GALLUP
VALENCIA
CALIFORNIA REGION
YAVAPAI
PRESCOTT
YUMA
MARICOPA
PHOENIX
GILA
GLOBE
PINAL
FLORENCE
PIMA
TUCSON
SANTA CRUZ
NOGALES
COCHISE
BISBEE
GRAHAM
SAFFORD
GREENLEE
CLIFTON
CATRON
RIO GRANDE REGION
GRANT
SILVER CITY
HIDALGO
LORDSBURG
ARIZONA
NEW MEXICO
COMPREHENSIVE FRAMEWORK STUDY
LOWER COLORADO REGION
VEGETAL COVER
1965

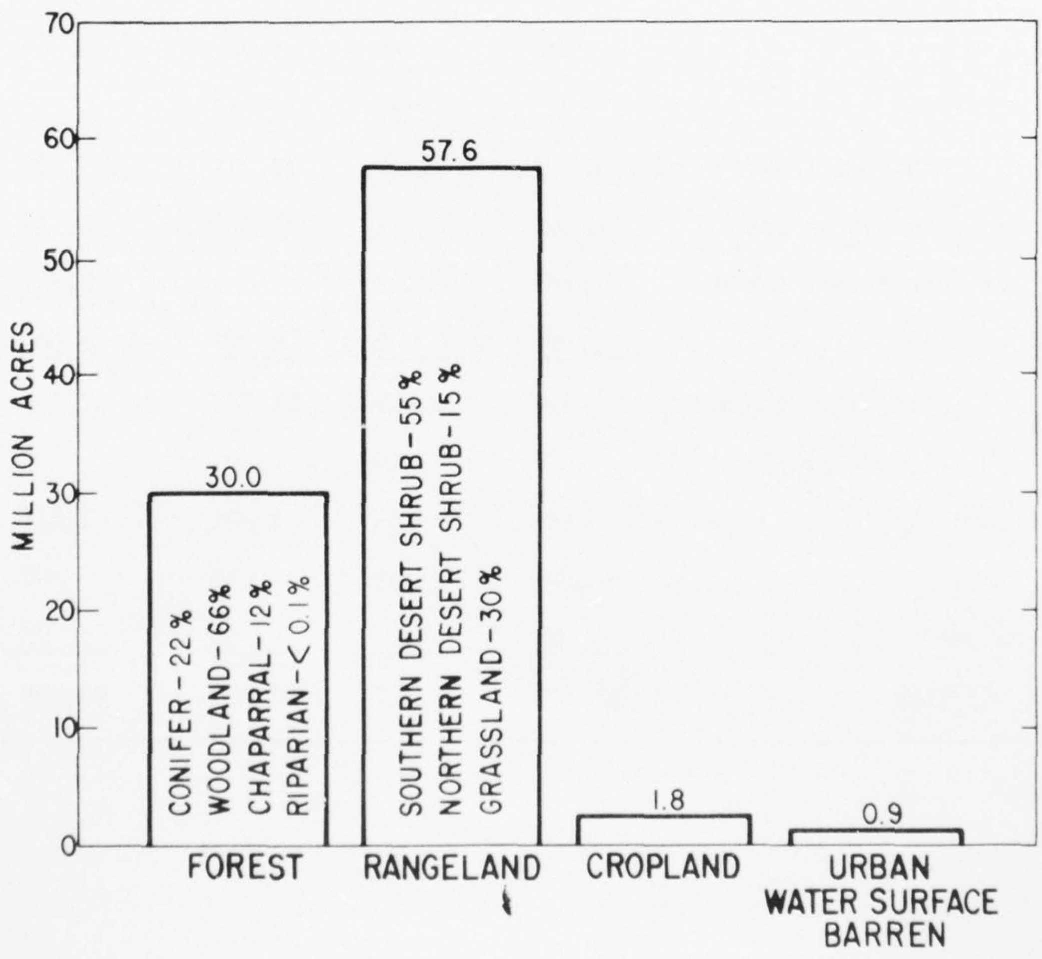
M7-S-21431B-N

Table B-10
Vegetal Cover and Related Categories - 1965
Lower Colorado Region

Unit: 1,000 Acres

	Lower Main Stem Subregion	Little Colorado Subregion	Gila Subregion	Total Lower Colorado Region
Conifer	1,068	1,702	3,752	6,522
Woodland	7,396	5,609	6,898	19,903
Chaparral	439	--	3,027	3,466
Riparian	52	--	54	106
Subtotal (Forest Land)	8,955	7,311	13,731	29,997
Southern Desert Shrub	17,111	--	15,026	32,137
Northern Desert Shrub	5,628	2,919	0	8,547
Grassland	3,765	6,940	6,197	16,902
Subtotal (Rangeland)	26,504	9,859	21,223	57,586
Urban & Industrial	129	19	365	513
Cropland	332	63	1,421	1,816
Water	249	13	78	340
Barren	26	--	50	76
Total	36,195	17,265	36,868	90,328

FIGURE B-7
VEGETAL COVER AND RELATED CATEGORIES-1965
TOTAL AREA-90.3 MILLION ACRES



Grassland - FS

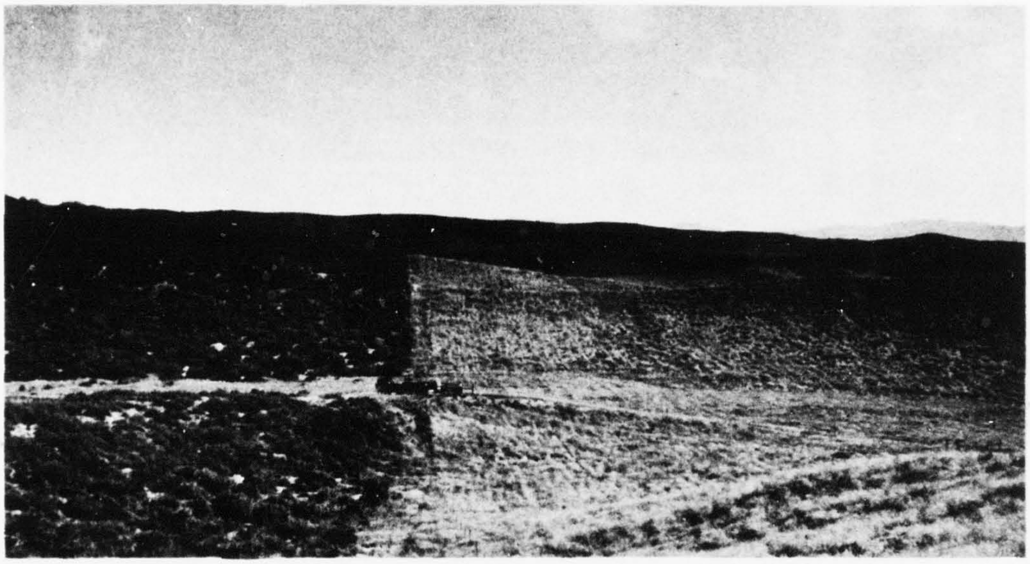
Riparian Vegetation

Northern Desert Shrub

Southern Desert Shrub

Coniferous Forest

Oak Woodland



Chaparral

Pinon-Juniper

Table B-11
Uses of the Land - 1965
Lower Main Stem Subregion

Unit: 1,000 Acres

Land Resource Groups	Area of 2/ LRG's (1965)	Cultivation		Grazing	Timber Production	Urban & Industrial	Outdoor Recreation		Designated Wilderness	Military	Mineral Production	Fish & Wildlife		Watershed		Trans. and Utilities
		Irrig.	Non-Irrig.				3/ Desig.	Un-Desig.				Desig.	Un-Desig.	Class.	Un-Class.	
Cropland 1/	332	267	5	132	0	-	-	250	0	-	-	-	332	0	332	20
Range	26,504	0	0	20,600	-	-	3,203	20,612	0	3,652	4	1,148	23,929	0	26,504	100
Forest	8,955	0	0	7,238	873	-	1,034	5,705	0	-	1	675	7,493	0	8,955	45
Urban	129	-	-	-	-	129	10	30	0	-	-	-	128	0	129	56
Barren & Other	26	0	0	0	0	-	-	26	0	0	0	0	26	0	26	-
Total	35,946	267	5	27,970	873	129	4,247	26,623	0	3,652	5	1,823	31,908	0	35,946	221

1/ Includes irrigated pasture, acres planted but not harvested, acres developed for irrigation but idle or fallow in 1965, farmsteads, farm roads, farm irrigation canals, etc.

2/ Land Resources Groups.

3/ Includes National Parks, City Parks, County Parks, Public Campgrounds, etc.

Note: Dash indicates small acreage.

Table B-12
Uses of the Land - 1965
Little Colorado Subregion

Unit: 1,000 Acres

Land Resource Groups	Area of 2/ LRG's (1965)	Culvitation		Grazing	Timber Production	Urban & Industrial	Outdoor Recreation		Designated Wilderness	Military	Mineral Production	Fish & Wildlife		Watershed		Trans. and Utilities
		Irrig.	Non-Irrig.				3/ Desig.	Un-Desig.				Desig.	Un-Desig.	Class.	Un-Class.	
Cropland 1/	63	28	16	36	0	-	-	52	0	-	-	-	63	0	63	3
Range	9,859	0	0	9,381	-	-	175	7,985	0	21	5	8	9,851	3	9,856	32
Forest	7,311	0	0	7,187	1,419	-	26	6,886	0	-	2	8	7,303	12	7,299	20
Urban	19	-	-	-	-	19	2	2	0	-	-	-	18	0	19	8
Barren & Other	0	0	0	0	0	-	0	0	0	0	0	0	0	0	0	-
Total	17,252	28	16	16,604	1,419	19	203	14,925	0	21	7	16	17,235	15	17,237	63

1/ Includes irrigated pasture, acres planted but not harvested, acres developed for irrigation but idle or fallow in 1965, farmsteads, farm roads, farm irrigation canals, etc.

2/ Land Resources Groups.

3/ Includes National Parks, City Parks, County Parks, Public Campgrounds, etc.

Note: Dash indicates small acreage.

Table B-13
Uses of the Land - 1965
Gila Subregion

Unit: 1,000 Acres

Land Resource Groups	Area of 2/ LRG's (1965)	Culvitation		Grazing	Timber Production	Urban & Industrial	Outdoor Recreation		Designated Wilderness	Military	Mineral Production	Fish & Wildlife		Watershed		Trans. and Utilities
		Irrig.	Non-Irrig.				3/ Desig.	Un-Desig.				Desig.	Un-Desig.	Class.	Un-Class.	
Cropland 1/	1,421	895	-	412	0	-	-	1,000	0	-	-	-	1,333	0	1,421	88
Range	21,223	0	0	20,777	-	-	655	12,000	10	402	13	12	21,157	4	21,219	123
Forest	13,731	0	0	10,291	3,166	-	401	8,000	851	51	50	7	13,681	20	13,719	65
Urban	365	-	-	-	-	365	36	100	0	-	-	-	65	0	365	100
Barren & Other	50	0	0	0	0	-	0	50	0	-	0	0	50	0	50	-
Total	36,790	895	-	31,480	3,166	365	1,092	21,150	861	453	63	19	36,286	24	36,774	376

1/ Includes irrigated pasture, acres planted but not harvested, acres developed for irrigation but idle or fallow in 1965, farmsteads, farm roads, farm irrigation canals, etc.

2/ Land Resources Groups.

3/ Includes National Parks, City Parks, County Parks, Public Campgrounds, etc.

Note: Dash indicates small acreage.

Table B-14
Uses of the Land - 1965
Lower Colorado Region

Unit: 1,000 Acres

Land Resource Groups	Area of 2/ LRG's (1965)	Culvitation		Grazing	Timber Production	Urban & Industrial	Outdoor Recreation		Designated Wilderness	Military	Mineral Production	Fish & Wildlife		Watershed		Trans. and Utilities
		Irrig.	Non-Irrig.				3/ Desig.	Un-Desig.				Desig.	Un-Desig.	Class.	Un-Class.	
Cropland 1/	1,816	1,160	21	580	0	-	-	1,302	0	-	-	-	1,728	0	1,816	111
Range	57,586	0	0	50,758	-	-	4,033	40,597	10	4,075	22	1,168	54,937	7	57,579	255
Forest	29,997	0	0	24,716	5,458	-	1,461	15,591	851	51	53	690	28,477	24	29,973	130
Urban	513	-	-	-	-	513	48	132	0	-	-	-	211	0	513	164
Barren & Other	76	0	0	0	0	-	0	76	0	-	0	0	76	0	76	-
Total	89,988	1,160	21	76,054	5,458	513	5,542	57,698	861	4,126	75	1,858	85,429	31	89,957	660

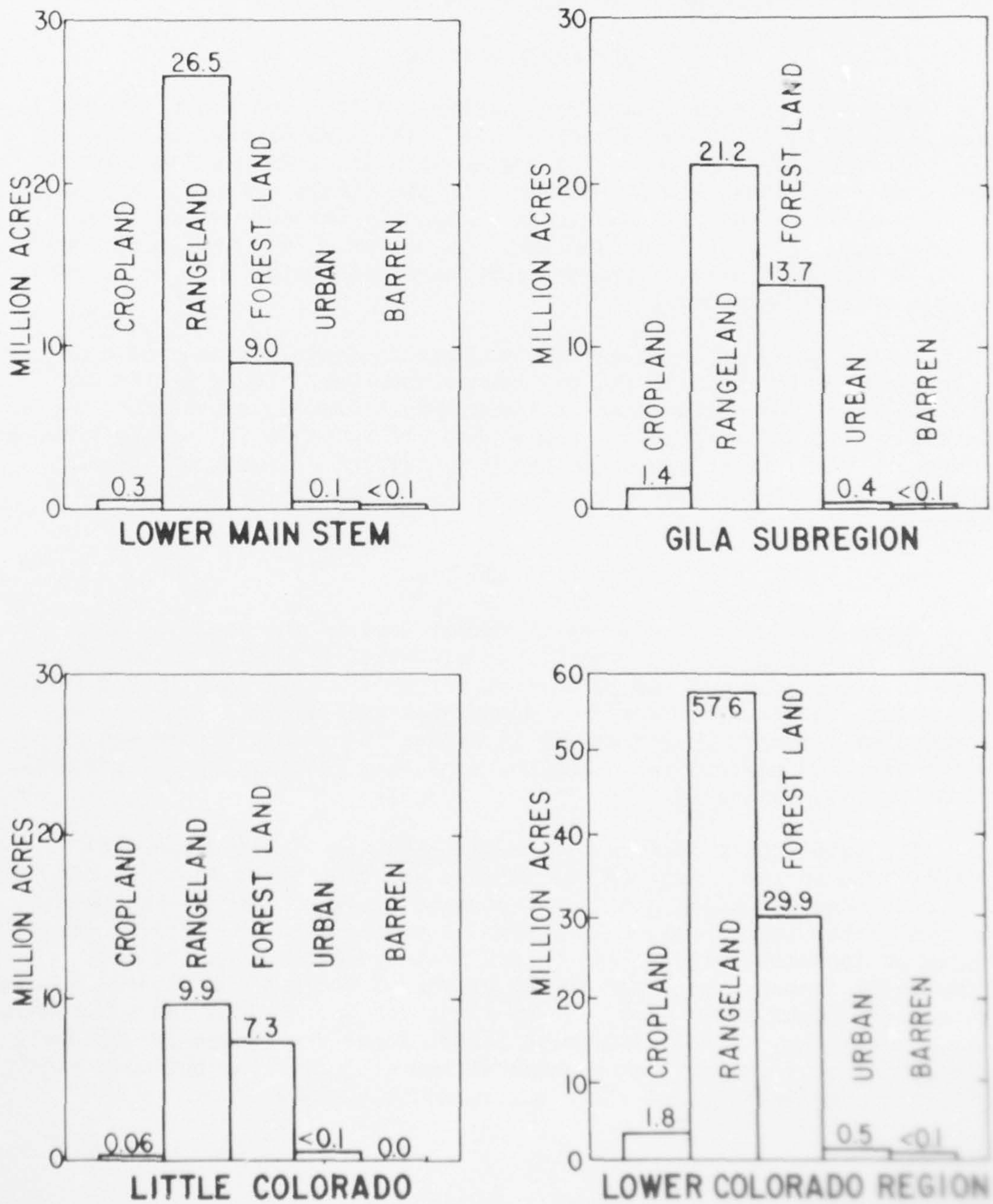
1/ Includes irrigated pasture, acres planted but not harvested, acres developed for irrigation but idle or fallow in 1965, farmsteads, farm roads, farm irrigation canals, etc.

2/ Land Resources Groups.

3/ Includes National Parks, City Parks, County Parks, Public Campgrounds, etc.

Note: Dash indicates small acreage.

FIGURE B-8
LAND AREA BY RESOURCE GROUPS-1965



AD-A043 928 LOWER COLORADO REGION STATE-FEDERAL INTERAGENCY GROUP F/G 8/6
LOWER COLORADO REGION COMPREHENSIVE FRAMEWORK STUDY. APPENDIX X--ETC(U)
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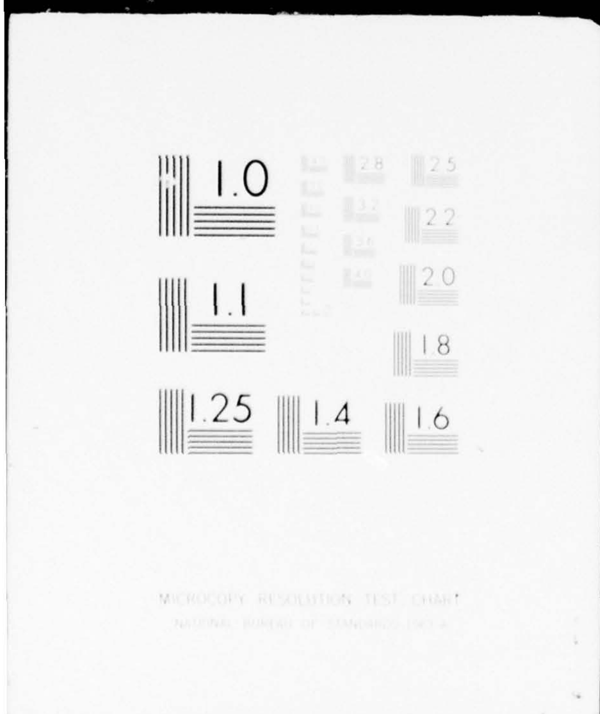


1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963-A

The dry cropland is located on gently to moderately sloping lands above 4000 feet elevation with annual precipitation of 16 inches or more. The most successfully dry farmed area is found between 5000 and 8000 feet in elevation with 20 inches or more average annual precipitation. Crop failure in years of below average annual precipitation is significant below these limits. Other problems in nonirrigated farming include short growing season, which limits the choice of crops, and the low precipitation rate during the growing season.

Livestock Grazing

The total area available for grazing in 1965 was about 76 million acres, which is about 84 percent of the total land area of the Region. It is distributed throughout the Region with about 28 million acres in the Lower Main Stem, 17 million acres in the Little Colorado, and 31 million acres in the Gila Subregion. About 21 percent of the total grazing land is in private ownership, 14 percent state and county ownership, 20 percent in Indian Trust, and the remaining 45 percent is owned by the Federal Government.

The native grazing lands of the Lower Colorado Region present a wide variance in complexities and resource values. These variations are the result of differences in topography, climate, elevations, vegetative types, and soil type. Lands that are suitable for use by domestic livestock will, under proper management, support a livestock industry indefinitely and continue to be an important and integral part of the economic framework of the Region.

Timber Production

There are 30 million acres of forest land in the Region. The forests generally occur at the higher elevations, usually above 4000 feet in elevation. Of the 30 million acres of forest land in the Region, 5.5 million acres are classed as commercial timberlands. Of the total commercial forests, 69 percent is in Federal ownership, 1 percent is state land, 23 percent is on Indian lands, and the remaining 7 percent is in private ownership.

The outstanding feature of the distribution of the commercial timber type in the Region is the largely unbroken block that extends for more than 300 miles along the Colorado Plateau. Ninety-one percent of the timber in this block is Ponderosa pine and is the largest single block of Ponderosa pine in the United States. Other areas of the commercial timber type occur on the crests of the small scattered mountain ranges and peaks above 4700 feet in elevation in the Gila and Lower Main Stem Subregions. These coniferous forest areas are generally too small and scattered to support an economical timber operation, but have high esthetic, recreation, and other environmental values.

Timber Resource

Phoenix, capitol city of Arizona, ranks as one of the Nation's fastest growing cities; the heart of the States industrial empire, and a major tourist attraction. Rapid expansion envelopes lands previously used for irrigated agriculture.

Urban

Urban uses occupied about 513,000 acres in the Region in 1965. These range from 158,000 acres in the Phoenix metropolitan area to small towns of less than a square mile. Average urban population densities are generally lowest for the large cities with their sprawling suburbs. Industrial users of land are generally within urbanized areas; only the mining industry occupies significant amounts of land outside of urban areas.

Outdoor Recreation

Practically all the Region has something of interest to the recreationist. The forest and rangelands provide a wide variety of outdoor recreation opportunities. The Region is unique in that it has desert environment for enjoyment in winter and mountains that provide cool summer recreation opportunities. The mountains also provide winter sports opportunities. Areas most valuable for recreation are those which have special attraction such as forests, rivers, streams, lakes; and areas of unusual archeological, historical, botanical, scenic, and geological values. For example, the wonders of the Grand Canyon attract tourists and recreationists from around the world.

The extensive areas of public lands provide almost unlimited opportunities for dispersed recreation and general enjoyment, the open spaces of the forest, mountain, and desert environment.

Wilderness and Primitive Areas

Within the Region in 1965 were 13 areas classified for wilderness management. These areas, totaling nearly 1½ million acres, included 6 wilderness areas, and 7 primitive areas. Wilderness areas are designated by Congressional action and any changes would require legislation, whereas, primitive areas are administratively established.

Areas within the Wilderness Preservation System are closed to all forms of motorized transportation. They are open to most forms of outdoor recreation, to hunting and fishing, to grazing of livestock (where this use was established prior to the effective date of the Wilderness Act), and for other uses, provided the wilderness character of the area is preserved. No structure or installation may be constructed and harvesting of timber is not permitted within the wilderness areas. Other than the trail systems, the only facilities permitted are limited to those essential for sanitation, fire prevention, and the preservation of wilderness values.

Mineral Production

The actual acreage used for mineral production in 1965 (75,000 acres) is a very small percentage of the total land area. Although

Mineral Production--necessary for the Nation's welfare and a major contributor to the Region's economy. About 60 percent of the Nation's copper is produced in regional open-pit mines located in the Lower Colorado Region.

small in extent, these lands are intensively used. Their economic importance is great and their compatibility with other uses is low. These lands are almost entirely in private ownership.

Low grade mineral deposits occur over large areas. However, in most places mineral extraction from these deposits will be delayed until future demands and technology make it feasible to mine these areas.

Transportation and Utilities

In 1965, 660,000 acres were used for transportation and utility purposes in the Region. This use generally keeps pace with the regional growth and population. Some facilities such as roads, railroads, and airports effectively alter other land uses, but these mostly exist over such a large area they do nothing more than break up the country into large blocks. Other facilities such as telephone, electric power, and pipeline rights-of-way may modify existing uses. In most cases, proper management of the rights-of-way produces benefits such as improved livestock forage and increased water yield.

Fish and Wildlife

Most of the water and land within the hydrologic region are of value to fish and wildlife. It is estimated that approximately 76.4 million acres of the Region contribute materially as important habitat for game and nongame fish and wildlife and most acres are available for fishing and hunting. Only 3.6 percent of the Region is managed and administered principally for fish and wildlife by the several state fish and game agencies, the Bureau of Sport Fisheries and Wildlife, or Indian and other private land owners.

Over 40 species of game occur throughout nearly all of the Region. Big game occur on approximately 72 million acres, small game on nearly 90 million acres, and waterfowl on 42,000 acres of suitable habitat. More than 710 species of nongame birds and mammals occur throughout the Region.

Military and Related Uses

Most of the land used for military and related purposes in the Region is desert or semiarid mountainous terrain. This land was selected for military and related uses because it was isolated from developed areas. Generally the land is not readily suited for agricultural uses and does not yield minerals in economically significant quantities.

Watershed

Every acre in the Region can be considered as watershed, and management of every resource and activity has an effect upon water

yield. Water yields vary depending upon the topography, climate, vegetation, and soils. Conditions of the watershed are affected by past and present use.

The forest lands of the Region contribute an average of about 2.8 million acre-feet of water annually to streamflow and important but unmeasured quantities of water to underground aquifers. About 31,000 acres of regional lands are included in classified watershed to provide for high quality domestic water to local municipalities.

Hydrologic studies indicate that water yield improvement programs can provide effective and efficient means of augmenting existing water supplies in water-deficient areas.

Other Uses

Other uses, not shown in Tables B-11 through B-14, include archeological and historic sites, scientific research sites, and small areas of unusual esthetic or scenic value. Although these areas do not usually involve large acreages, they are very important to the public.

MINERAL RESOURCES AND DEVELOPMENT

In 1965, and for the preceding century, the principal mining areas of the Region were those producing copper in the southeastern portion of the Region. However, increasingly important quantities of such minerals as copper and uranium, and most recently, petroleum are being now produced in the northern part of the Region.

Copper's predominant position in the Region's mineral industry is unique in the Nation, overshadowing all the combined remainder with 60 percent of the national output. Moreover, because of the huge volume of copper ore mined, significant amounts of silver and gold are produced as byproducts of the copper production.

Along with copper, the current leading mineral commodities are uranium, sand and gravel, lead-zinc, and cement. This commodity-mix has persisted since the late 1950's; prior to that period, uranium was not produced in volume in the Region, and lime was ranked as one of the five leading minerals produced.

There is an excellent possibility that petroleum will soon be one of the top five and will probably maintain that position through the end of the century.

Because of the recent and current construction of fossil-fueled thermoelectric generating plants, coal production is becoming increasingly important in the Region.

The construction industry has been and is currently in an apparently long-term uptrend, which has proportionally influenced the production of sand, gravel, and cement in the Region.

Mineral Production and Value

Mineral production in the United States, Upper Colorado Region, and Lower Colorado Region in base year 1965 is recorded in Table B-15.

The table reflects company confidentiality where required. Petroleum is the catchall term for crude oil, natural gas, liquid petroleum gases, helium, etc. Likewise, uranium data include byproduct vanadium because the two commodities commonly are produced from the same ores in the northern part of the Colorado Plateau.

Table B-15 also serves as a reference to all the mineral commodities produced in the Colorado Region during the 1947-1966 interval. The tabular listing and footnotes 3, 4, and 5 cover the minerals produced in 1965--footnote 6 completed the post-World War II picture. This

"minerals register" may seem impressive at first glance, but upon further examination, it is apparent that some items are unimportant to a comprehensive framework study. For example, it is clear that in 1965 the value of copper production in the Lower Colorado Region was predominant in the minerals industry, whereas the value of iron ore output was quite insignificant.

Table B-15 implies that a wide variety of metalliferous ores was mined in 1965, but many of these commodities were byproducts. In the Lower Colorado Region more than 10 million pounds of molybdenum was produced, but no molybdenum ore was mined because it was recovered as a byproduct from copper ore from several mines. Regionwide, virtually no gold and silver ores were mined; most of the gold and silver was recovered as byproducts from copper operations in the Lower Colorado Region. Thus, it is evident that only a few of the 40 or so mineral commodities listed in Table B-15 dominate the production and value figures in the Lower Colorado Region.

Markets

In general, mineral fuels produced in the Lower Colorado Region find markets outside the Region and metals are marketed nationwide.

The Lower Colorado Region is an important exporter of uranium, the only mineral fuel currently produced in substantial volume. Oil and gas have only recently been discovered and produced, and output of coal, although intermittently produced for decades, has been negligible in importance. Uranium is marketed nationwide, and some foreign sales contracts have also been recorded. Future market potential, both domestic and foreign, is excellent.

Oil and gas production is expected to increase in the near-term with distribution to southwest and West Coast markets most probable. Coal output is projected to increase markedly to fuel a thermal power plant in southern Nevada; over the long-term, however, coal's future in the Region does not appear to offer significant increases in the dollar value of mineral production in the Region.

Almost all metals output leaves the Lower Colorado Region, mostly in the form of mill concentrates, or smelter product, for further upgrading or refining and subsequent industrial use elsewhere in the Nation. During the 1960's, molybdenum was the only metal consistently produced in quantities sufficient to satisfy some foreign demand. Periodically, the Nation has been a net exporter of copper, and obviously the Region's vast annual copper output was largely responsible for this occasionally favorable balance-of-trade item. Statistically, the Nation has hovered about self-sufficiency in copper output for many years, usually falling short of a balance by some small margin.

Table B-15 - Mineral production in the United States, Upper Colorado Economic Region, and Lower Colorado Economic Region in 1965[1/]

Mineral	United States: Quantity	United States: Value (thousands)	Upper Colorado Region: Quantity	Upper Colorado Region: Value (thousands)	Lower Colorado Region: Quantity	Lower Colorado Region: Value (thousands)	Value contribution to total U.S. production (percent): Upper Colorado Region	Value contribution to total U.S. production (percent): Lower Colorado Region	Value contribution to total U.S. production (percent): Colorado Region
Mineral fuels:									
Coal, bituminous ..... thousand short tons	512,088	$2,276,022	10,905	$54,245	352	$1,816	2.4	0.1	2.5
Helium ..... thousand cubic feet	4,365,068	66,687	80,583	2,821	2/	2/	4.2	2/	2/
Natural gas ..... million cubic feet	16,039,753	2,494,542	687,905	85,398	3,106	376	3.4	n	3.4
Natural gas liquids:									
Natural gasoline ..... thousand gallons	7,288,070	494,354	127,843	7,735	-	-	1.6	-	1.6
LP gases ..... do	11,257,267	417,249	456,377	16,679	-	-	4.0	-	4.0
Petroleum ..... thousand 42-gallon barrels	2,848,462	8,158,150	67,118	181,330	2/	2/	2.2	2/	2/
Uranium ore ..... short tons	4,362,614	83,915	942,282	19,517	1,835,898	34,318	23.3	40.9	64.2
Other fuels[3/]	XX	137,714	XX	5,780	XX	3,307	XX	XX	XX
Total mineral fuels	XX	14,129,000	XX	374,000	XX	40,000	2.6	0.3	2.9
Metals:									
Copper ..... short tons	1,351,734	957,028	3,822	2,707	802,026	567,834	0.3	59.3	59.6
Gold ..... troy ounces	1,705,190	59,682	35,188	1,232	155,060	5,427	2.1	9.1	11.2
Iron ore ..... thousand long tons	84,472	804,498	114	787	8	51	0.1	n	0.1
Lead ..... short tons	301,147	93,959	20,470	6,387	10,016	3,125	6.8	3.3	10.1
Manganiferous ore (5 to 35 percent Mn) ..... do	332,763	2/	-	-	50,090	2/	-	2/	2/
Mercury ..... 76-pound flasks	19,582	11,176	-	-	158	90	-	0.8	0.8
Molybdenum ..... thousand pounds	77,310	120,801	50,715	78,609	10,312	17,296	65.1	14.3	79.4
Silver ..... thousand troy ounces	39,808	51,469	1,755	2,269	6,550	8,469	4.4	16.5	20.9
Vanadium ..... short tons	5,226	18,284	4,788	15,753	109	381	86.2	2.1	88.2
Zinc ..... do	611,153	178,284	51,210	14,953	59,825	17,469	8.4	9.8	18.2
Other metals[4/]	XX	2/	XX	2,150	XX	2/	XX	XX	XX
Total metals	XX	2,388,000	XX	125,000	XX	621,000	5.2	26.0	31.2
Nonmetals:									
Asbestos ..... short tons	118,275	10,162	-	-	3,469	441	-	4.3	4.3
Clays ..... thousand short tons	55,089	203,772	293	650	150	278	0.5	0.3	0.8
Gypsum ..... do	10,035	37,423	-	-	585	2,147	-	5.7	5.7
Lime ..... do	16,794	232,939	2/	2/	448	8,205	2/	3.5	2/
Pumice ..... do	3,483	6,640	52	78	1,161	1,516	1.2	22.8	24.0
Sand and gravel ..... do	908,049	957,416	6,895	7,126	19,685	22,578	0.7	2.4	3.1
Stone ..... do	780,072	1,203,618	2,473	3,807	3,410	5,925	0.3	0.5	0.8
Other nonmetals[5/]	XX	2,265,000	XX	2/	XX	11,413	XX	XX	XX
Total nonmetals	XX	4,916,000	XX	43,000	XX	53,000	0.9	1.1	2.0
Grand total mineral production[6/]	XX	21,433,000	XX	542,000	XX	714,000	2.5	3.3	5.9

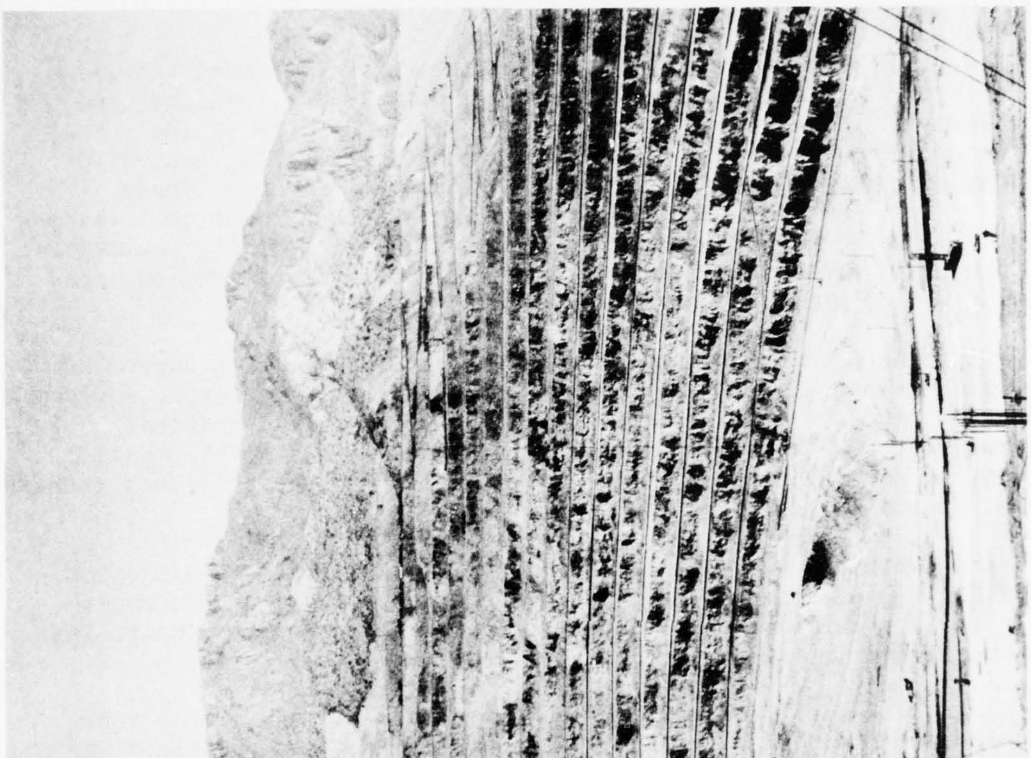
n Negligible. XX Not applicable.
1/ Source: Bureau of Mines Minerals Yearbook, Volume I, 1965, and files of the Denver and San Francisco Offices of Mineral Resources. Values are unadjusted 1965 dollars.
2/ Figure withheld to avoid disclosing individual company confidential data; value included with value of other fuels, other metals, and other nonmetals.
3/ Other fuels (in order of value) are gilsonite and natural carbon dioxide in the Upper Colorado Region and helium and petroleum (values combined but withheld) in the Lower Colorado Region.
4/ Other metals are tungsten, pyrite, and tin in the Upper Colorado Region and pyrites, tin, and tungsten in the Lower Colorado Region.
5/ Other nonmetals are sodium carbonate, potash, phosphate rock, salt, and lime (value withheld) in the Upper Colorado Region and cement, perlite, feldspar, mica, diatomite, and salt in the Lower Colorado Region.
6/ Total mineral production for 1965, as listed in the table and footnotes 3, 4, and 5, was comprised of 29 mineral commodities in the Upper Colorado Region and 30 mineral commodities in the Lower Colorado Region. Other mineral commodities produced in the Region since World War II are as follows: Upper Colorado Region--manganese, manganiferous ores, columbite-tantalite, beryllium, rare earths, clays (varieties other than those produced in 1965), feldspar, barite, fluorspar, lithium, gypsum, and mica. Lower Colorado Region--coal, manganese, columbite-tantalite, beryllium, rare earths, clays (varieties other than those produced in 1965), brucite, barite, fluorspar, and vermiculite.

PRESENT STATUS

Considering the continuing new mine developments and expansions at established operations in the Region (and elsewhere in the Nation), a marked surplus production potential seems virtually certain at least until the mid-1970's. Therefore, with due consideration to political and social instability in several important foreign copper-producing countries, the Region's output seems destined to become much more widely distributed through the 1970's, thus, periodically enhancing the Nation's balance-of-trade account.

Essentially all nonmetals production in the Lower Colorado Region is for internal use, mostly to meet regional construction industry needs. Typically bulky, low in unit value, and common to most areas, the more important nonmetallics--sand, gravel, cement, stone, gypsum, and clays--ordinarily are transported only short distances to markets.

Open-pit mine and concentrating facilities in Pima County, Arizona.



Open-pit copper mine at Morenci, Arizona.

LAND TREATMENT AND MANAGEMENT

Effective management of an area requires a well-founded knowledge of the interrelationships among climate, plants, soils, geology, and other factors. Management objectives may be one or more of the following: increased water yield, improved water quality, control of erosion and sediment yield, and reduced floodwater damage. These objectives may be achieved through variations in management of livestock forage, timber and other vegetative types, wildlife habitat, residential and commercial areas in respect to location (zoning), recreation, crop production, and other resources.

Proper management and use of land are dependent upon a number of factors. These are: past use of the land, ownership patterns, soils, vegetative type(s), climate, and physiography. Any well-balanced watershed management program must consider the use and development of such resources as timber, forage, and wildlife, and social values such as recreation and esthetics.

Land ownership and administration influence watershed management. Because a high percent of the Region (64 percent) is in public ownership, public agencies have the greatest opportunity and responsibility for watershed improvement.

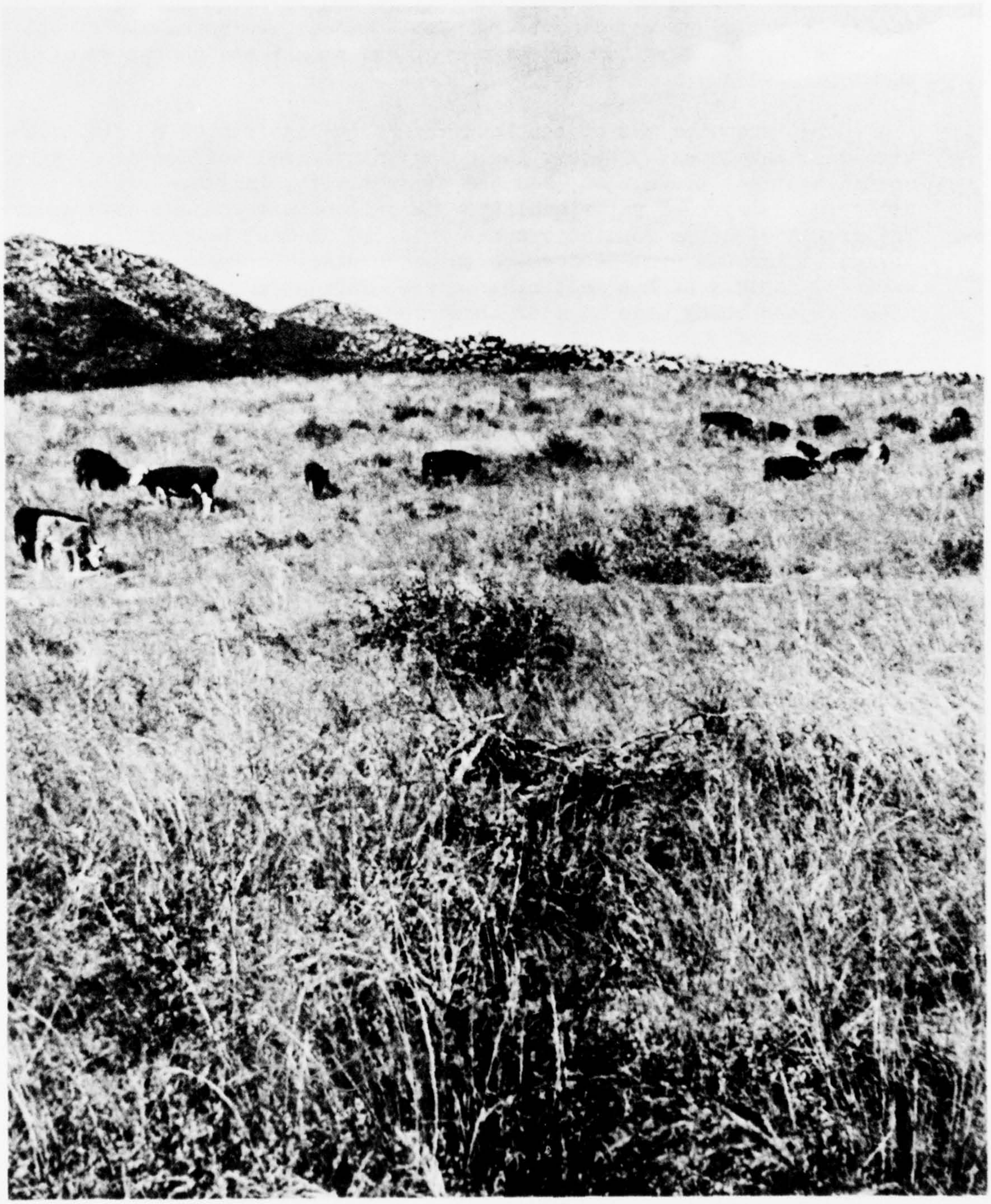
Large blocks of Federal lands and most Indian lands are in contiguous ownership. When the ownership pattern is not diversified and scattered, administrators can more effectively protect and enhance watershed values as part of the multiple-use program.

The state and private lands have resulted from various public land laws. This resulted in these lands being interspersed with other ownerships. Planning and development of effective watershed management programs are very complex where many different ownerships and management policies are involved.

In order to select effective management and treatment practices, information such as soil depth, texture, origin and the nature of the underlying material must be evaluated. These factors determine the erodibility of the soil and its ability to receive, transmit, and store water.

The vegetative types within the Region represent extremes from the true desert and the ephemeral southern desert shrub type to the true alpine type. Each vegetative type requires different treatment and management programs, because of different erosion hazards, runoff conditions, and sediment and water yield potential.

Climate and physiography must also be considered in developing a watershed management program. The interrelationship of all or a



Area converted from chaparral to grass for increased water yield and improved forage

combination of some of the following factors have an influence. These factors are: slope and aspect, rainfall (amount, seasonal distribution, storm intensity, duration and pattern), and amount and character of snowfall.

More intensive use of the land resources has created a multitude of watershed management problems including: increased soil erosion, accelerated sediment production, reduced productivity, increased flood damage, and degraded water quality. Major land use changes have occurred. The growth of urban populations has resulted in land being shifted from irrigated agricultural production to urban use. Recreation demands have expanded rapidly as has most other uses. Through multiple-use management, attempts are being made to meet these increasing demands.

Erosion

Soil erosion within the Region is a significant problem. Erosion causes damage in the following ways: (1) sheet erosion and flood plain scour reduce productivity of the soil and increase costs, and (2) streambank and gully erosion result in land loss, land depreciation, fish and wildlife habitat damage, damage to improvements and facilities, and increased land management costs. Erosion damage can be materially reduced by proper land treatment and management.

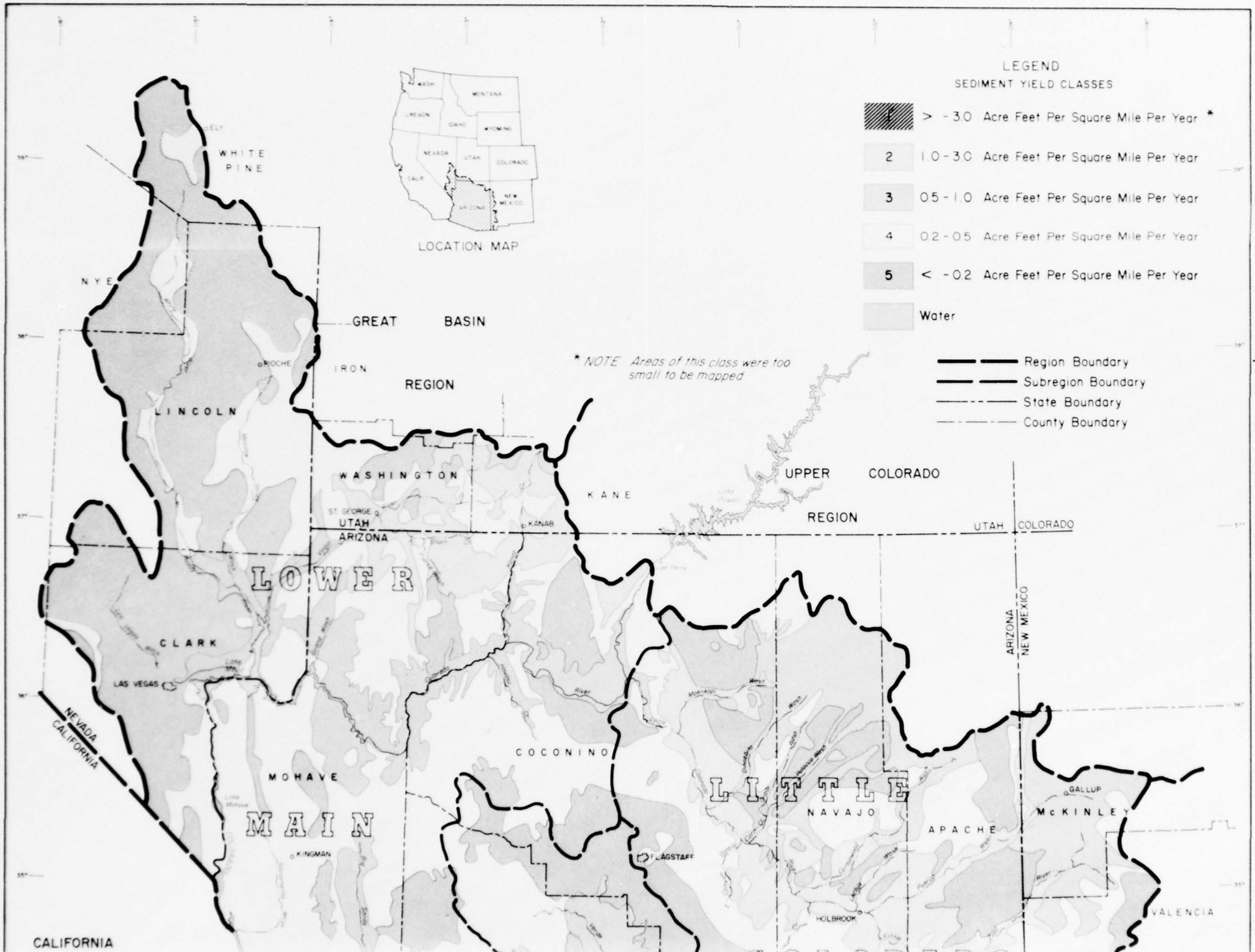
Approximately 60 percent of the land within the Region experiences slight to severe erosion and is generally considered to require some form of land treatment. The remaining 40 percent of the land does not require treatment because the measures have already been applied; the problem is minor; or, erosion treatment is not feasible.

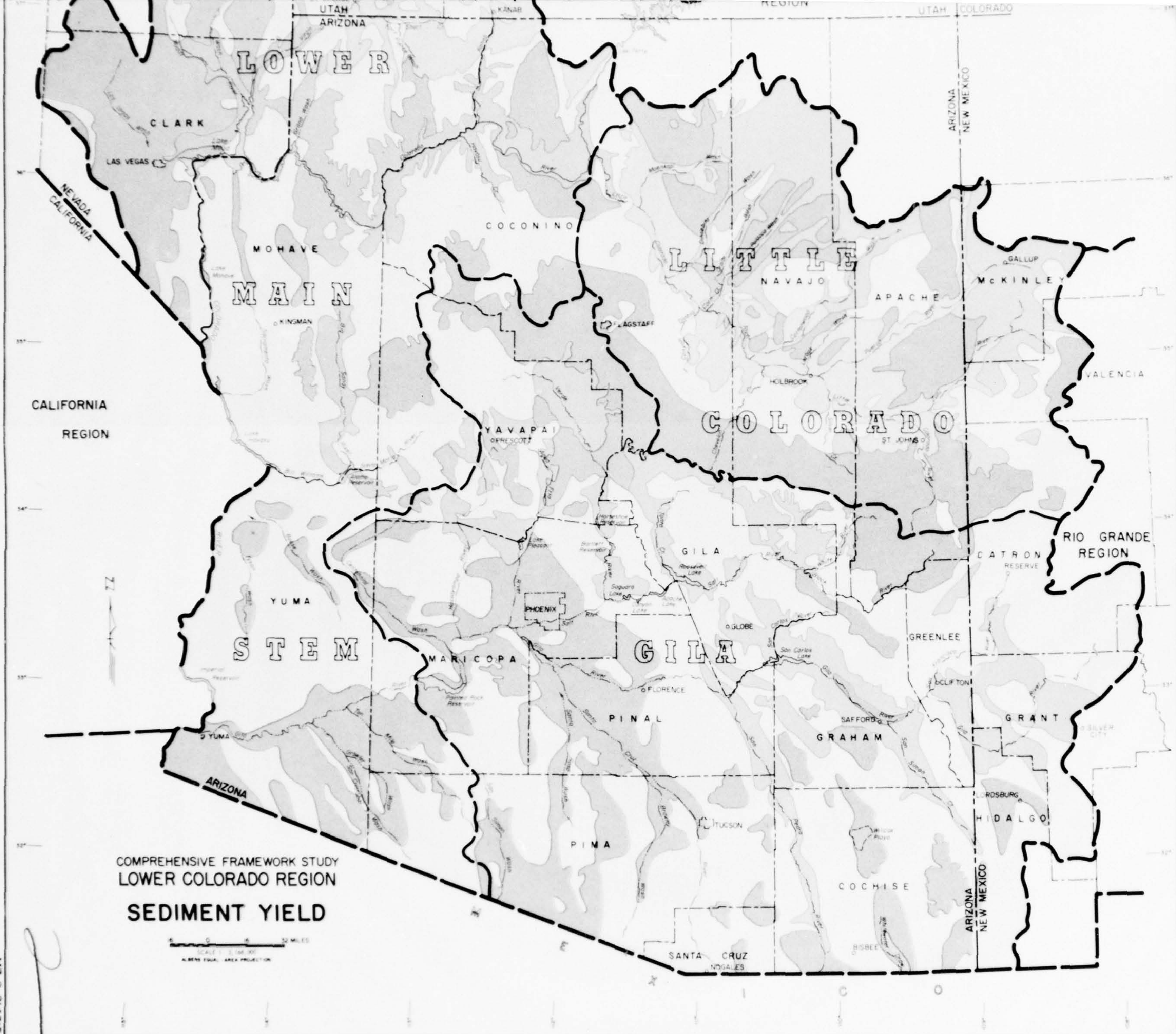
Erosion of high forest lands is usually slight and generally occurs in the form of sheet and gully erosion brought about as the result of road construction, heavy grazing, logging operations, or other uses that disturb the soil mantle. At the lower elevations, areas of moderate to severe gully and sheet erosion occur.

Erosion of rangeland varies widely from severe to slight, although generally it is slight. Areas of severe erosion are characterized by valley trenching and moderate to severe sheet erosion.

Average annual erosion damage on forest land and rangeland (1965 prices and conditions) is estimated to be about $6.1 million, of which about 50 percent is due to loss in land productivity.

Erosion of cultivated land is primarily in the form of sheet erosion but bank erosion also destroys some of these lands. Some scouring occurs when these lands are flooded. Average annual losses on cultivated land from erosion in the Region were estimated at about $527,000 under 1965 prices and conditions, of which about three-fourths are due to loss of productivity.


LEGEND
SEDIMENT YIELD CLASSES
1 > -3.0 Acre Feet Per Square Mile Per Year *
2 1.0-3.0 Acre Feet Per Square Mile Per Year
3 0.5-1.0 Acre Feet Per Square Mile Per Year
4 0.2-0.5 Acre Feet Per Square Mile Per Year
5 < -0.2 Acre Feet Per Square Mile Per Year
Water
Region Boundary
Subregion Boundary
State Boundary
County Boundary
* NOTE Areas of this class were too small to be mapped
LOCATION MAP
GREAT BASIN REGION
UPPER COLORADO REGION
LOWER
MAIN
LITTLE
WHITE PINE
NYE
LINCOLN
CLARK
IRON
WASHINGTON
KANE
COCONINO
MOHAVE
NAVAJO
APACHE
McKINLEY
VALENCIA
ELY
PIOCHE
ST GEORGE
KANAB
LAS VEGAS
KINGMAN
FLAGSTAFF
HOLBROOK
GALLUP
UTAH
ARIZONA
COLORADO
NEW MEXICO
NEVADA
CALIFORNIA



COMPREHENSIVE FRAMEWORK STUDY
LOWER COLORADO REGION
SEDIMENT YIELD

M7-S-21431D-N

Table 39 in the Land Resources and Use, Watershed Management Appendix presents a breakdown of average annual erosion damage by subregion.

Sediment Yield

Sediment yield is the volume of sediment carried out of a watershed or to any point of concern within the Watershed. It is a function of both the amount of gross erosion in the watershed and the capability of the stream system to transport eroded materials. Sediment yield rates are grouped into five classes.

The following table shows the acreage and percentage of land in each sediment yield class in the Region by subregion.

Table B-16
Acreage and Percent of Land in Each Sediment Yield Class
Lower Colorado Region

Unit: 1,000 Acres

	Sediment Yield Classes									
	1		2		3		4		5	
	3.0*		1.0-3.0*		0.5-1.0*		0.2-0.5*		0.2*	
Subregion	Ac.	%	Ac.	%	Ac.	%	Ac.	%	Ac.	%
L.M. Stem	0	0	1,955	2.2	3,321	3.7	17,759	19.7	12,910	14.3
L. Colo.	0	0	3,167	3.5	3,861	4.3	4,866	5.4	5,358	6.0
Gila	0	0	0	0	5,467	6.1	21,517	23.9	9,806	10.9

* Acre-feet per square mile per year.

The Sediment Yield Map, following page XVIII-68, shows the general location and extent of sediment yield classes 2 through 5 within the Region.

Water Supply Deficiency

Decreasing ground-water level and limited surface-water supplies are major problems in most parts of the Region. Well drilling for the purpose of new land development is restricted in some areas. A deficiency in the supply of surface water results in improper livestock distribution in many grazing areas.

Average annual runoff varies widely. Runoff averages 0.05 inches or less in the desert to as much as 8 inches in the mountainous areas. There is a need to treat some watershed areas to increase and regulate

water yield in order to help fulfill the ever-increasing onsite and offsite water requirements. This requires carefully coordinated management practices that increase water yield, and simultaneously minimize impacts on or enhance other resource values.

Drainage Deficiency

Drainage problems within the Region are usually associated with irrigation and become apparent only after the land has been irrigated for some time. As new lands are developed, drainage problems may be expected.

Wildfire

Danger from wildfire on the forest and range lands may be and usually is present some place in the Region during every month of the year. Wildfire usually destroys both plant cover and the litter or duff leaving the soil wholly unprotected and resulting in decreased infiltration, increased overland flows and accelerated erosion. Damages include sediment deposition in reservoirs, streams, and irrigation systems, and floodwater and sediment damage to urban and industrial developments. Wildfires bring about a destruction of the humus within the upper soil mantle, resulting in a lowering of infiltration rates, an acceleration of runoff, and sometimes producing the condition referred to as "nonwettability," with resultant increases in erosion rates and high sedimentation.

An average annual burned area from wildfire in the Region is about 45,000 acres (1965), about equally divided between range and forest land areas. The average annual damage (including the resource value lost and improvements) is estimated to be about $5.7 million.

Summary of Practices and Measures

Over the past several years, significant advances have been made in management practices and techniques by landowners and public land managers.

Although most land has had some treatment, there is no accurate method for determining what portion of the total area had received adequate land treatment and management by 1965. On an equivalent acre basis, using present standards, sufficient measures had been installed to adequately treat about 37 percent of the irrigated cropland in the Region. While most public forest and range lands utilized by domestic livestock are under some form of improved livestock management, only 15 percent of these lands benefit from completed management programs. Less than 10 percent of the commercial timberland in the Region has been developed and is being managed for the maximum production of timber products. An estimated 25 percent of the measures

and treatment needed for the efficient development and management of urban and other lands have been provided for based upon the 1965 needs of the people. In nearly all cases, the measures and practices meeting the standards in 1965 are expected to be inadequate in the near future because of improved technology and a limited useful life. All will require maintenance and rehabilitation.

Management programs, developments, and practices that have been installed on public and private lands as of 1965 include measures primarily for reducing erosion and sedimentation, and controlling runoff. Also installed are measures for improved grazing management. In the first category are: measures for bank and/or channel protection, stabilization structures, terraces, minor dikes and levees, floodwater diversions, floodways, and channel improvement. In the second category are improved grazing management, fencing, stock-water developments, and reseeding. In 1965, most land received some degree of wildfire protection. Vegetative and resource management have been provided on over 2,500 square miles. This is primarily for increased water yield and forage.

As of 1965, work involving 1,577 square miles in 11 upstream watersheds had been authorized. Of the total projects authorized, 6 had been completed.

PRESENT STATUS

FLOOD CONTROL

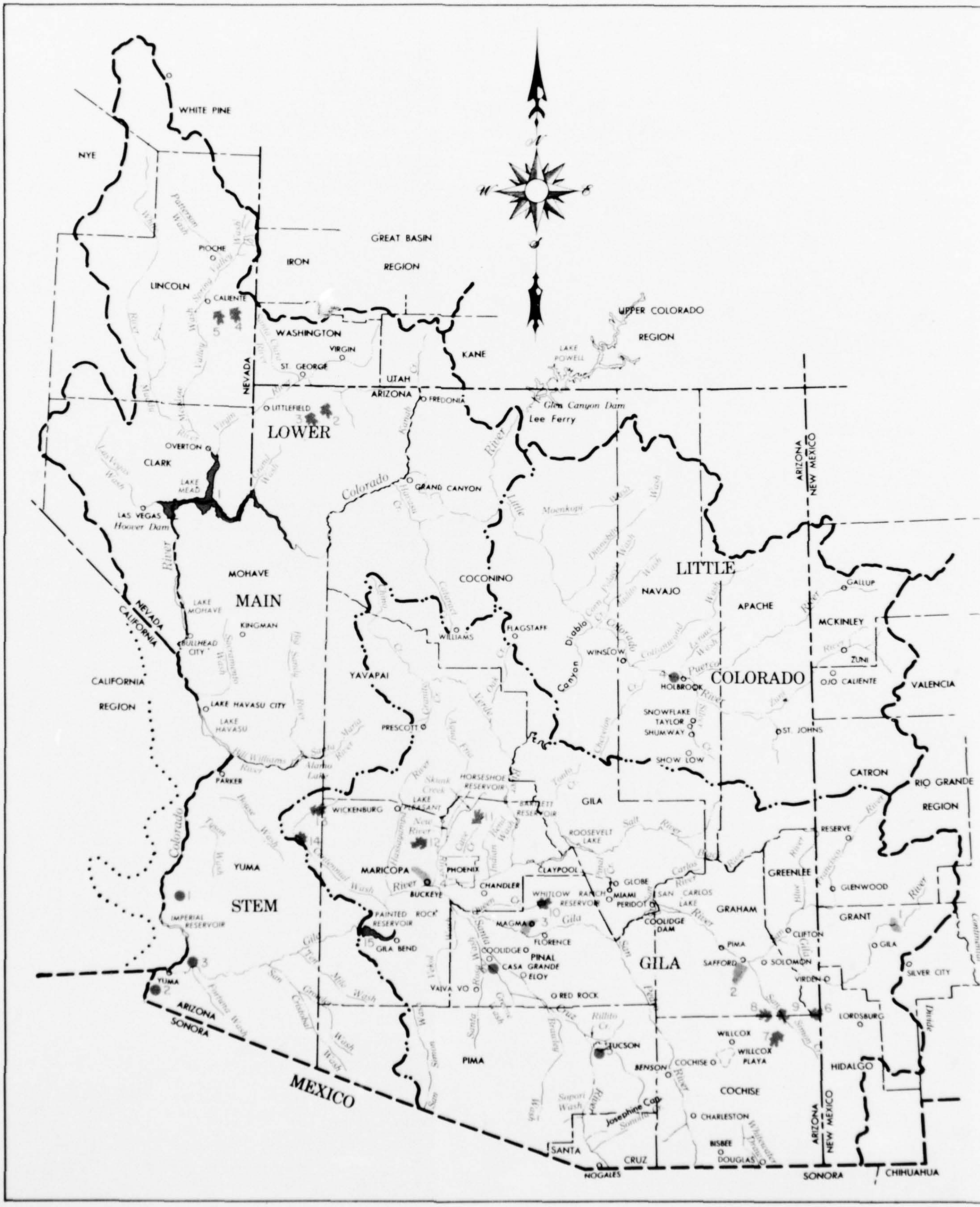
Major flood problems exist at unprotected cities and in highly developed agricultural areas throughout the Lower Colorado Region. Floods cause recurrent damage of major proportions by cutting streambanks, changing the shape and location of channels, and eroding farmlands; inundating farmlands and urban areas; and damaging and destroying irrigation, communication, utility and transportation facilities.

Floodwaters of the tributary streams are heavily laden with sediment eroded from the land surface and scoured from the channels. During summer floods on the tributaries, when the main streams are not usually in flood, the force of the peak flows from the side streams is dissipated rapidly in the main channel and much of the silt load is deposited, causing divided channels and meandering flow in the mainstreams.

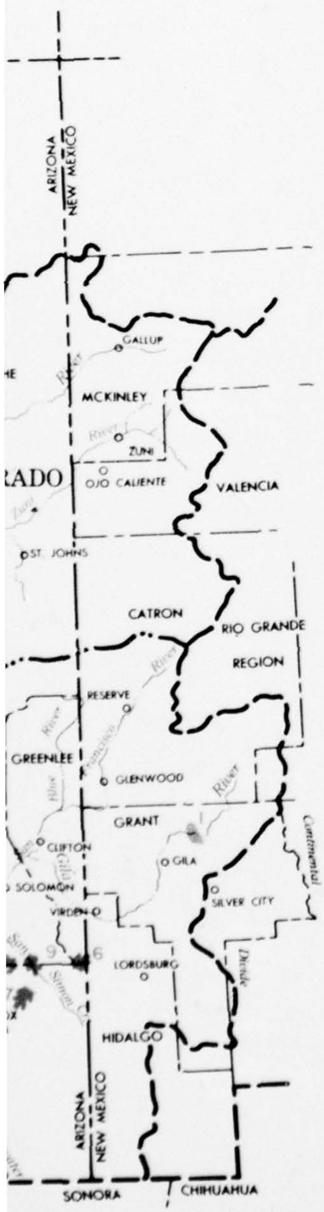
Flood control and flood damage prevention measures include flood forecasting, protective structures, watershed management and treatment practices, and flood plain management.

Flood forecasting includes the formulation and public dissemination of weather, river stage, and flood forecasts and warnings. These forecasts and flood warnings are provided to local people in areas threatened by floods to permit organizing for flood fighting and rescue activities. Agencies with operational responsibilities of dams and reservoirs use this information, together with that from their own hydrological networks in the drainage basin above their respective reservoirs, to regulate outflow from reservoirs to minimize downstream damages. Water year, seasonal and residual volume forecasts are made for 14 river gage locations in the Lower Colorado Region. These forecasts are made the first of each month during the potential flood season, January through May.

Flood protection structures include reservoirs, channel improvements, levees and dikes, channel stabilizations structures, and retarding basins for water and sediment. There are 19 existing reservoirs (1,000 acre-feet or more) with total flood control storage of 10,700,000 acre-feet providing structural protection for the Lower Colorado Region. These are supplemented by four major reservoirs in the Upper Colorado Region which control practically all inflow to Lake Mead. One recently completed major structure, Alamo Dam, provides an additional 838,000 acre-feet of flood control storage and will control floods originating in the Bill Williams River Basin. In addition, major reservoirs on the Gila, Salt, Verde, and Agua Fria Rivers provide some protection for the metropolitan area of Phoenix and the agricultural districts along the rivers. Flood protection measures which include about 143 miles of levees and 120 miles of channel improvements provide varying degrees of flood protection to urban and agricultural areas. See map following for existing improvements.



GREAT BASIN
REGION
UPPER COLORADO
REGION
LOWER
MAIN
STEM
LITTLE
COLORADO
GILA
CALIFORNIA
REGION
RIO GRANDE
REGION
MEXICO
NYE
WHITE PINE
LINCOLN
IRON
WASHINGTON
KANE
CLARK
MOHAVE
COCONINO
NAVAJO
APACHE
MCKINLEY
VALENCIA
CATRON
YAVAPAI
YUMA
MARICOPA
GILA
GREENLEE
GRAHAM
GRANT
PINAL
PIMA
COCHISE
HIDALGO
SANTA
CRUZ
NEVADA
UTAH
ARIZONA
CALIFORNIA
NEW MEXICO
SONORA
CHIHUAHUA
PIOCHE
CALIENTE
ST. GEORGE
VIRGIN
LITTLEFIELD
FREDONIA
OVERTON
LAKE MEAD
LAS VEGAS
Hoover Dam
LAKE POWELL
Glen Canyon Dam
Lee Ferry
GRAND CANYON
LAKE MOHAVE
KINGMAN
BULLHEAD CITY
LAKE HAVASU CITY
LAKE HAVASU
PARKER
WILLIAMS
FLAGSTAFF
WINSLOW
HOLBROOK
SNOWFLAKE
TAYLOR
SHUMWAY
SHOW LOW
ST. JOHNS
GALLUP
ZUNI
OJO CALIENTE
PRESCOTT
WICKENBURG
LAKE PLEASANT
HORSESHOE RESERVOIR
BARTLETT RESERVOIR
ROOSEVELT LAKE
PHOENIX
BUCKEYE
CHANDLER
CLAYPOOL
GLOBE
MIAMI
PERIDOT
SAN CARLOS LAKE
COOLIDGE DAM
WHITLOW RANCH RESERVOIR
MAGMA
FLORENCE
COOLIDGE
CASA GRANDE
ELOY
PAINTED ROCK RESERVOIR
GILA BEND
IMPERIAL RESERVOIR
YUMA
VAIVA VO
RED ROCK
TUCSON
BENSON
COCHISE
WILLCOX
WILLCOX PLAYA
CHARLESTON
BISBEE
DOUGLAS
NOGALES
PIMA
SAFFORD
SOLOMON
CLIFTON
VIRDEN
GILA
SILVER CITY
LORDSBURG
RESERVE
GLENWOOD
Colorado
River
Little
Puerco
Salt
Gila
San Pedro
Santa Cruz
Verde
Bill Williams
Canyon Diablo
Moenkopi



LEGEND

REGION BOUNDARY
SUBREGION BOUNDARY
STATE BOUNDARY
COUNTY BOUNDARY
COLORADO RIVER DRAINAGE
(U) UPSTREAM PROJECT
(D) DOWNSTREAM PROJECT

EXISTING (1965) PROJECTS

RESERVOIR WITH FLOOD CONTROL

1.	LAKE MEAD	(D)
2.	FLAT TOP	(U)
3.	IVERSON	(U)
4.	MATHEWS CANYON	(U)
5.	PINE CANYON	(U)
6.	RAILROAD WASH	(U)
7.	CREIGHTON	(U)
8.	H-X	(U)
9.	SAN SIMON	(D)
10.	WHITLOW RANCH	(U)
11.	CAVE CREEK	(U)
12.	MCMICKEN	(U)
13.	UPPER CENTENNIAL	(D)
14.	LOWER CENTENNIAL	(D)
15.	PAINTED ROCK	(D)

LEVEE AND CHANNEL PROJECTS

1.	COLORADO RIVER	(D)
2.	YUMA VALLEY	(D)
3.	GILA RIVER	(D)
4.	HOLBROOK	(D)
5.	TUCSON DIV.	(U)
6	GREENE WASH	(D)

WATERSHED PROJECTS *

1.	ARROYOS NO. 1	(U)
2.	FRYE-STOCKTON	(U)
3.	MAGMA	(U)
4.	WHITE TANKS	(U)

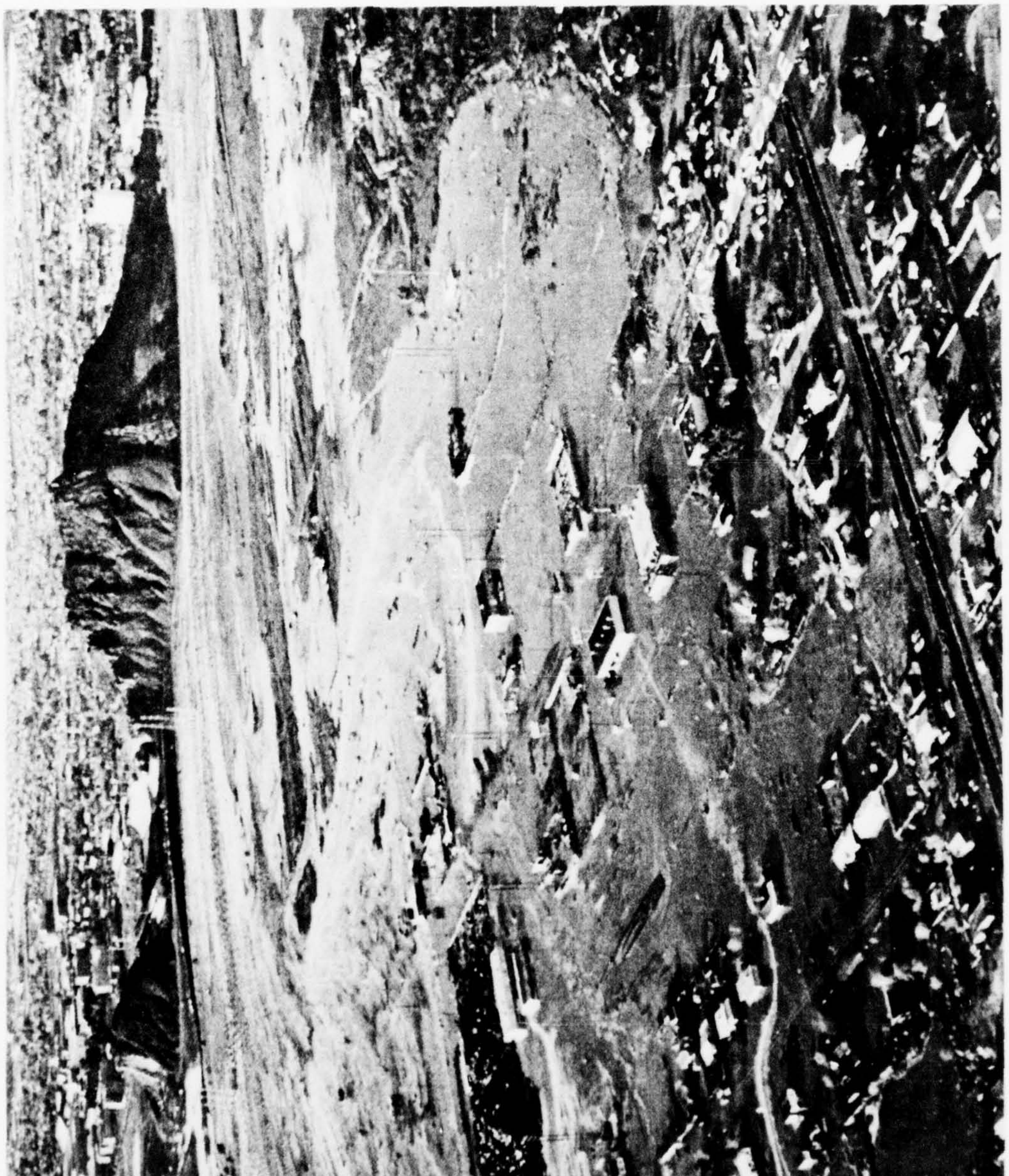
* THESE PROJECTS INCLUDE RESERVOIRS, CHANNELS, LEVEES, AND RELATED LAND TREATMENT AND MANAGEMENT MEASURES.

COMPREHENSIVE FRAMEWORK STUDY
LOWER COLORADO REGION

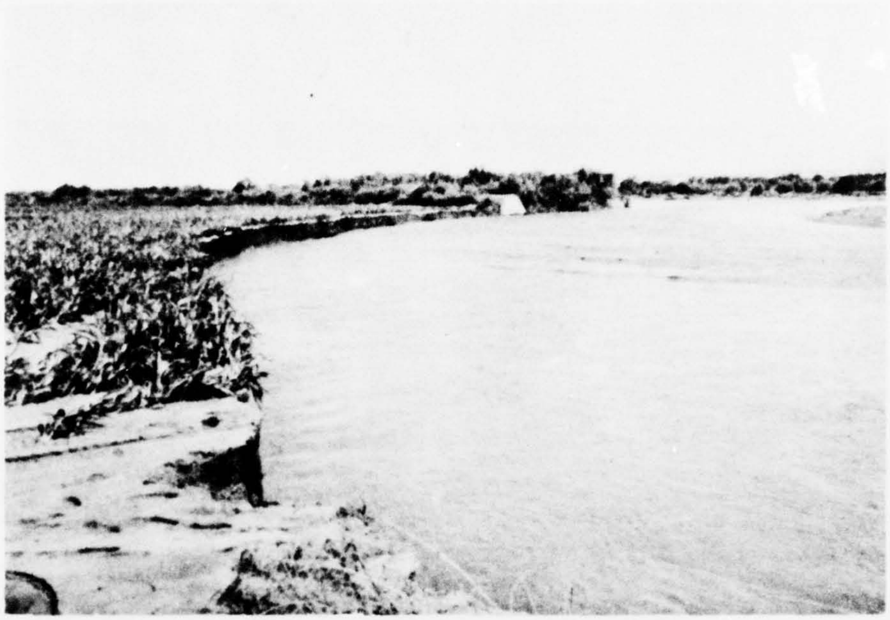
EXISTING IMPROVEMENTS FOR FLOOD CONTROL AND RELATED PURPOSES

SCALE 20 0 20 40 60 MILES

2



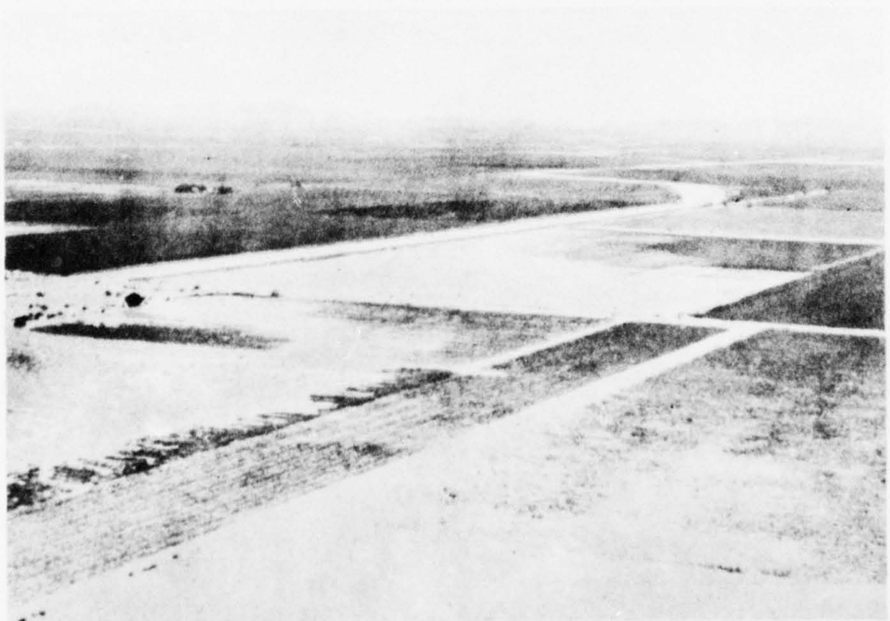
The Salt River overflowed its banks at Tempe, Arizona, December 1965-January 1966.



Streambank erosion

Irrigation canal and road damage

Floodwater and sediment damage to young citrus grove



Floodwaters spreading over irrigated cropland

PRESENT STATUS

Land treatment and management practices under existing programs, while smaller in scope, have significant offsite effects in reducing erosion and sedimentation, controlling runoff, and prolonging the life of downstream detention and storage facilities. Practices and measures installed as of 1965 which have these effects are reported in the land treatment and management section.

Prior to and including 1965, flood plain management programs to insure proper use of flood plain lands have not been widely established in the Region. Statutes of the several states concerning flood plain management are inadequate to prevent encroachment on overflow areas. Flood plain regulations used by communities to exercise some control on the extent and type of development on lands subject to flooding include use of zoning ordinances, health regulations, building codes and subdivision regulations.

Completed flood control structures consisting of reservoirs, levees, channel improvements, and watershed projects have prevented an estimated $110,400,000 cumulative flood damages to 734,000 acres through 1965. Although the flood damages prevented are an impressive amount, future flood damages are likely to rise because of continued agricultural and urban growth in flood prone areas.

In 1965, there were approximately 164,000 acres of urban land and over one million acres of cropland subject to flooding within the Region. In addition, about 4.3 million acres of forest and rangeland are subject to flood damage.

Flood damages are classified as either downstream or upstream. In general, downstream flood damages are those occurring on the main stems and major tirbutaries, and upstream flood damages are those experienced on the smaller tributaries (having drainage areas of less than 250,000 acres) 1/.

Based on the 1965 level of flood plain development and protection, estimated average annual flood damage within the Region is estimated to be about $40.8 million. Of this amount approximately $21.3 million is agricultural damage and $19.5 million is nonagricultural damage. Of the total damage, 30 percent is in downstream areas and 70 percent is in upstream areas. The estimated average annual flood damages under 1965 conditions are presented in Table B-17.

1/ (a) This presentation of flood damage data by upstream-downstream categories in no way determines the agency responsible for the solution of the flood damage problems and (b) data presented include major urban damages in upstream areas.

Table B-17
Estimated Average Annual Flood Damage - 1965
Lower Colorado Region

Subregion and Study Area	Flood damage 1/ - ($1,000) Forest & range resources	Forest & range facilities	Crop & pasture	Other agricultural	Land	Residential & commercial	Industrial & utilities	Public facilities	Study Area Total
LOWER MAIN STEM									
Colorado River	10	135	656	411	197	394	99	1,268	3,170
Virgin River	2	35	84	104	32	78	104	251	690
Las Vegas Wash	1	20	0	0	7	740	198	209	1,175
Lower Gila River	0	5	1,609	1,864	181	245	44	1,137	5,085
Subregion Total	13	195	2,349	2,379	417	1,457	445	2,865	10,120
LITTLE COLORADO									
Little Colorado River, New Mexico	0	12	79	32	18	41	19	147	348
Little Colorado River, Arizona(incl. Puerco River)	1	28	48	69	10	219	40	280	695
Little Colorado River, Arizona (below Puerco River)	5	75	35	55	7	214	132	864	1,387
Subregion Total	6	115	162	156	35	474	191	1,291	2,430
GILA									
Gila River, New Mexico	4	48	163	73	49	7	2	112	458
Gila River, (State line to Coolidge Dam)	6	62	498	517	159	191	134	615	2,182
Gila River, (Coolidge to Salt River)	0	2	1,185	933	323	621	272	1,014	4,350
Santa Cruz	5	50	2,940	1,207	597	1,355	688	1,588	8,439
Salt River	10	75	639	657	136	4,478	1,453	1,812	9,260
Gila River (Salt River to Painted Rock)	0	15	1,223	935	287	170	56	834	3,520
Subregion Total	25	252	6,648	4,322	1,551	6,822	2,605	5,975	28,200
Region Total	44	562	9,159	6,857	2,003	8,753	3,241	10,131	40,750

1/ Damages are based on July 1965 prices, economic conditions and project conditions.

PRESENT STATUS

IRRIGATION AND DRAINAGE

Irrigation

In base year 1965, there were approximately 1,530,000 acres of land developed for irrigation in the Lower Colorado Region. About 370,000 of these developed acres were out of production because of insufficient water supplies, poor water quality, uneconomic pumping costs, government farm programs, and other factors. Of the remaining 1,190,000 acres irrigated, a substantial portion was plagued by a similar list of problems. About 125,000 acres were double cropped in 1965.

Approximately 76 percent of the Region's irrigation is in the Gila Subregion with about 22 percent and 2 percent occurring in the Lower Main Stem and Little Colorado Subregions, respectively. Nearly 94 percent of the total irrigation is in the southern third of the Region where long growing seasons favor double cropping and increase the irrigation water demand. See irrigated land map following.

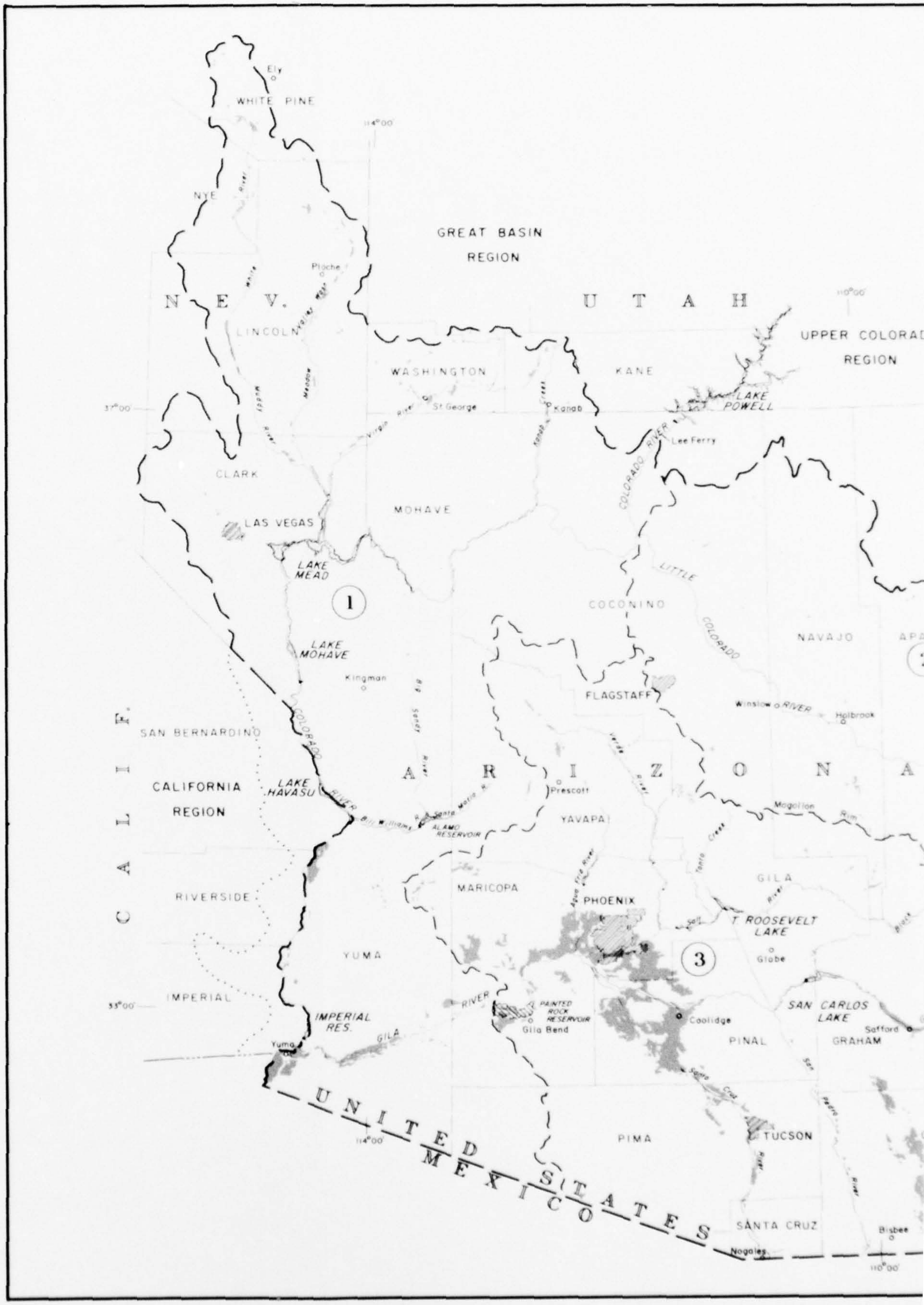
Of the 1,315,000 acres under irrigation in the Region in 1965 (including double cropped acres), only about 280,000 acres depend entirely on surface waters. About 417,000 acres require supplemental ground water and 618,000 acres depend entirely on a ground-water source of supply. Table B-18 shows the distribution of irrigated lands according to water sources.

Due to the high average summer temperatures in the major portion of the irrigated area, a high evapotranspiration rate occurs requiring average irrigation withdrawal rates of over 6 acre-feet per acre and in some areas withdrawal rates may be over 10 acre-feet per acre because of soils having high infiltration rates.

Seven crops accounting for nearly 95 percent of the total harvested acreage under irrigation in the Region are listed in Table B-19.

There is a very intense recycling and reuse of irrigation water. Consumptive use and percolation result in the concentration of dissolved solids in the water. The results are that damaging concentrations are being built up at the lower elevations of the Gila Subregion, and in the lower part of the Lower Main Stem Subregion. Ground water is annually becoming less capable of offsetting these effects because of the dropping water table and deterioration of water quality.

Thus, it appears that there was sufficient water available in the Region in 1965 to irrigate the 1,315,000 acres but the profits from a large portion of the irrigated acreage were being reduced by deteriorating water quality and the increasing costs of pumping ground water. Table B-20 presents estimated water withdrawals for irrigation purposes in 1965 for the Region by subregion and state.



GREAT BASIN REGION
UPPER COLORADO REGION
CALIFORNIA REGION
N E V.
U T A H
A R I Z O N A
C A L I F.
UNITED STATES
MEXICO
WHITE PINE
NYE
LINCOLN
CLARK
LAS VEGAS
WASHINGTON
KANE
MOHAVE
COCONINO
NAVAJO
FLAGSTAFF
YAVAPAI
MARICOPA
PHOENIX
GILA
PINAL
GRAHAM
PIMA
TUCSON
SANTA CRUZ
YUMA
SAN BERNARDINO
RIVERSIDE
IMPERIAL
Ely
Pioche
St George
Kanab
Lee Ferry
LAKE POWELL
LAKE MEAD
LAKE MOHAVE
LAKE HAVASU
Kingman
Prescott
Winslow
Holbrook
Mogollon Rim
ALAMO RESERVOIR
T ROOSEVELT LAKE
Globe
SAN CARLOS LAKE
Safford
Coolidge
PAINTED ROCK RESERVOIR
Gila Bend
IMPERIAL RES.
Yuma
Bisbee
Nogales
COLORADO RIVER
LITTLE COLORADO RIVER
GILA RIVER
Bill Williams R.
Santa Maria R.
Virgin River
1
2
3
114°00'
110°00'
37°00'
33°00'

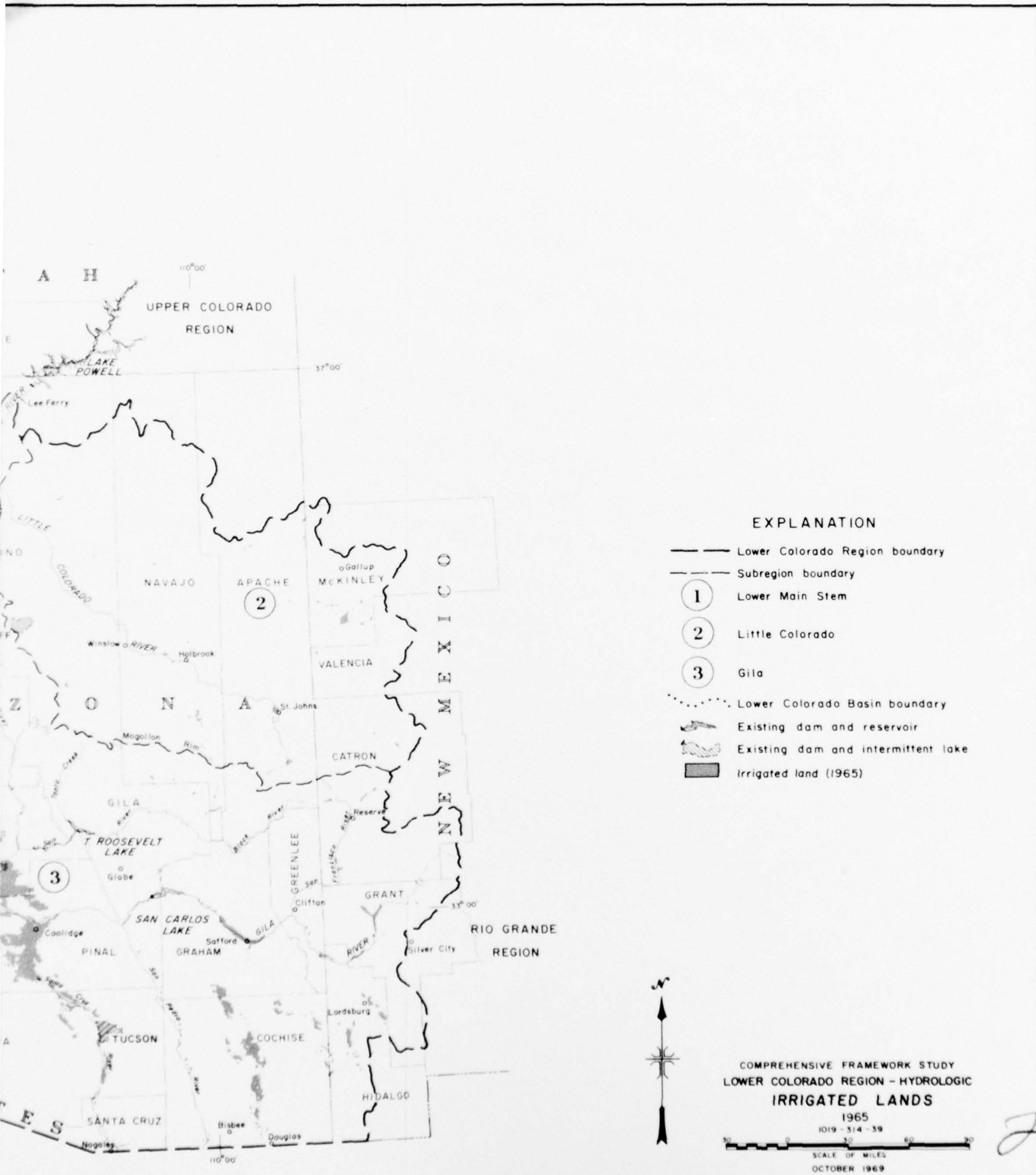
UPPER COLORADO REGION
LAKE POWELL
Lee Ferry
NAVAJO
APACHE
McKINLEY
Gallup
VALENCIA
CATRON
GILA
GREENLEE
GRANT
GRAHAM
PINAL
COCHISE
HIDALGO
SANTA CRUZ
TUCSON
Winslow
Holbrook
St Johns
Reserve
Globe
Clifton
Safford
Coolidge
Silver City
Lordsburg
Bisbee
Douglas
Nogales
ROOSEVELT LAKE
SAN CARLOS LAKE
RIO GRANDE REGION
NEW MEXICO
EXPLANATION
Lower Colorado Region boundary
Subregion boundary
1 Lower Main Stem
2 Little Colorado
3 Gila
Lower Colorado Basin boundary
Existing dam and reservoir
Existing dam and intermittent lake
Irrigated land (1965)
COMPREHENSIVE FRAMEWORK STUDY
LOWER COLORADO REGION - HYDROLOGIC
IRRIGATED LANDS
1965
1019-314-39
SCALE OF MILES
OCTOBER 1969

Table B-18
Irrigated Cropped Areas by Water Source - 1965
Lower Colorado Region

Unit: 1,000 Acres

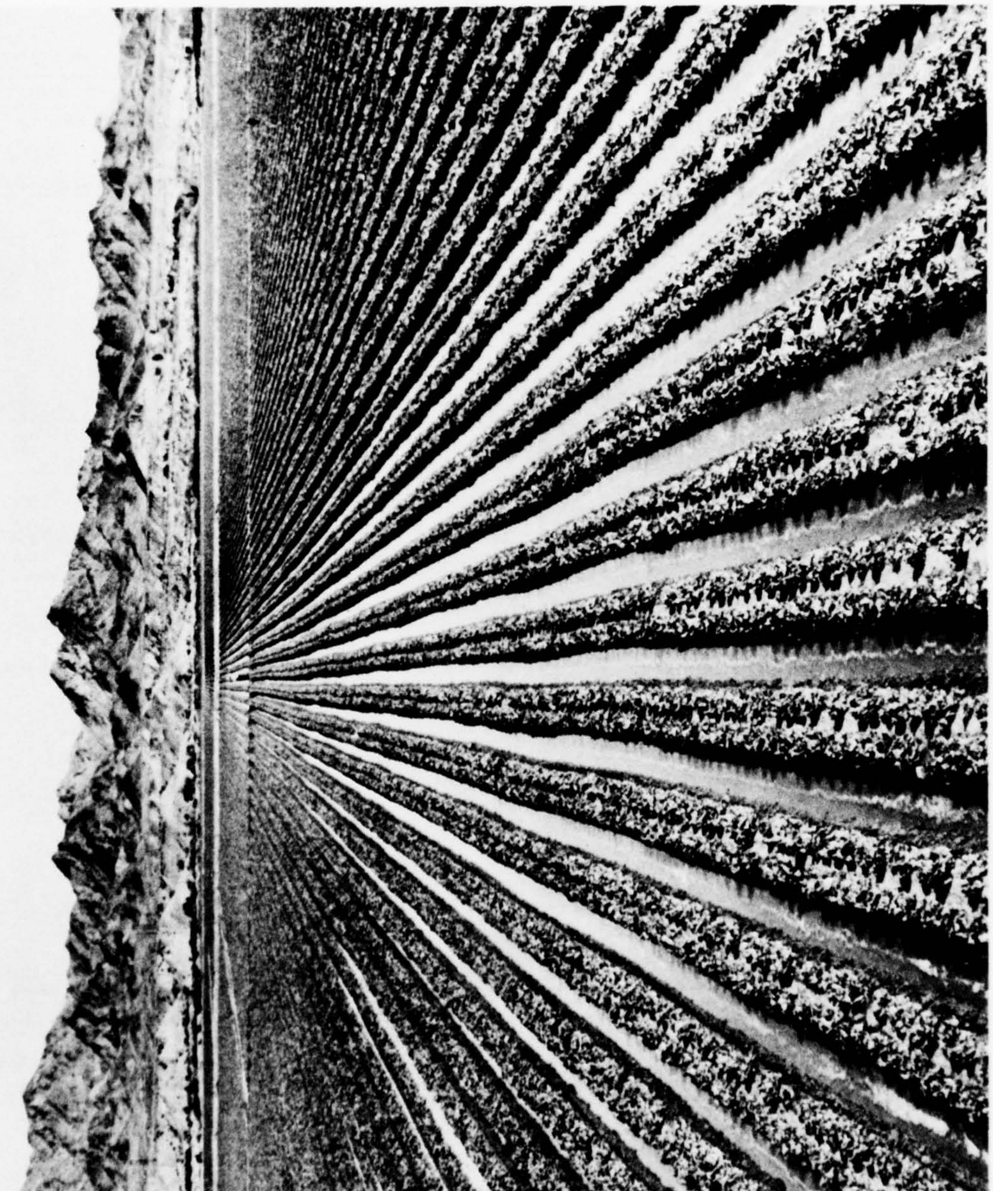
Subregion	Total 1/ Cropped Lands	Irrigated by Water Source: Surface	Ground	Surface and Ground
Lower Main Stem	293	249	38	6
Arizona	(223)	(194)	(23)	(6)
Nevada	(49)	(36)	(13)	(0)
Utah	(21)	(19)	(2)	(0)
Little Colorado	28	16	4	8
Arizona	(22)	(10)	(4)	(8)
New Mexico	(6)	(6)	(0)	(0)
Gila	994	15	576	403
Arizona	(961)	(9)	(554)	(398)
New Mexico	(33)	(6)	(22)	(5)
Total Region (acres)	1,315	280	618	417

1/ Includes 125,000 acres of land double cropped, of which 29,000 acres were in the Lower Main Stem and 96,000 acres were in the Gila Subregion.

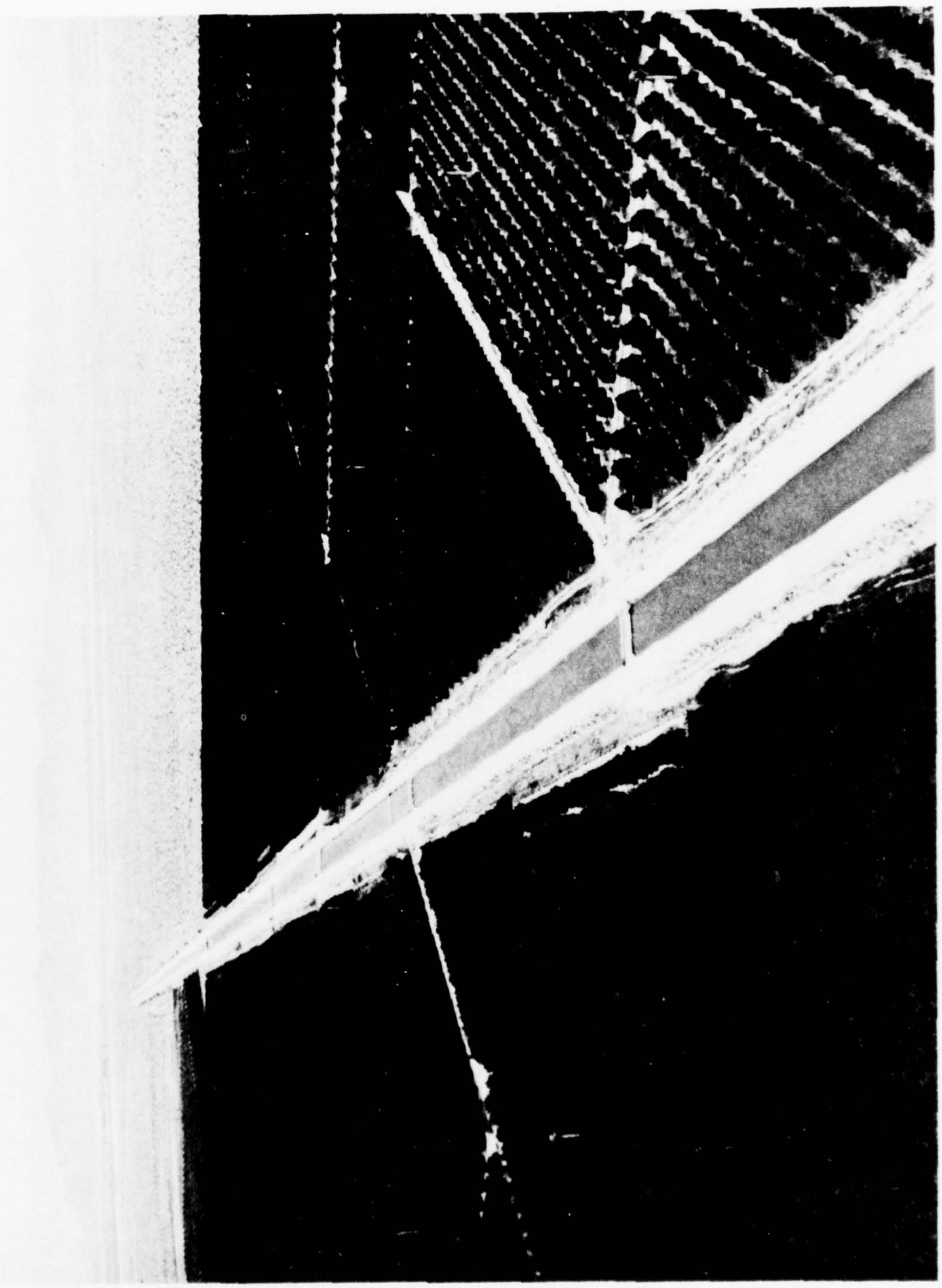
Table B-19
Acreage of Major Crops - 1965
Lower Colorado Region

Unit: 1,000 Acres

Crop	Acreage
Alfalfa	208
Barley	170
Citrus	39
Cotton	345
Pasture	92
Sorghum	186
Vegetables	75



Irrigated lettuce fields



Irrigated citrus groves

Harvesting irrigated lettuce

Table B-20
Water Withdrawals for Irrigation - 1965 1/
Lower Colorado Region

Unit: 1,000,000 Acre-Feet

Subregion and State	Surface	Ground	Total
Lower Main Stem	1.83	0.44	2.27
Arizona	(1.62)	(0.39)	(2.01)
Nevada	(0.12)	(0.04)	(0.06)
Utah	(0.09)	(0.01)	(0.10)
Little Colorado	0.05	0.06	0.11
Arizona	(0.04)	(0.06)	(0.10)
New Mexico	(0.01)	--	(0.01)
Gila	1.13	4.26	5.39
Arizona	(1.09)	(4.19)	(5.28)
New Mexico	(0.04)	(0.07)	(0.11)
Total	3.01	4.76	7.77

1/ Estimated actual withdrawal was less than estimated requirement.

Drainage

Drainage problems in the Lower Colorado Region are generally associated with irrigation. These problems have been caused by three factors: poor management of irrigation water, restricted permeability of layer or horizon in the soil, or topographic relief of the area being irrigated. Each of these factors, singly or in combination, causes water to accumulate in and/or on the soil faster than it can be used by plants, evaporate, or percolate through the soil. As a result, adequate aeration is precluded, thus adversely affecting plant production.

Millions of dollars have been spent on correcting drainage problems. These problems generally become apparent after the land has been irrigated for some time. Most of the land that has been irrigated has had some drainage problems.

The measures, practices, and facilities have been instrumental in saving and more efficiently using the available water and in treating the drainage problem.

MUNICIPAL AND INDUSTRIAL WATER

Water Use

The estimated withdrawal requirements for domestic, manufacturing, livestock, governmental, commercial and other M&I water uses in the Lower Colorado Region was 450,200 acre-feet in 1965. The estimated depletion requirement for these uses was 197,900 acre-feet. Estimated regional withdrawal and depletion for M&I water uses are shown in Figure B-9.

Domestic

Regional domestic uses of water, including municipal-domestic and rural domestic, had the largest withdrawal and depletion requirements of the M&I water uses. A population of 1,877,000 within the regional economic boundary had an average domestic withdrawal rate of 129 gallons per capita per day and an average domestic depletion rate of 65 gpcd. Domestic depletion requirements were estimated to be about 50 percent of domestic withdrawal requirements. The Gila Subregion had the largest subregional domestic requirement.

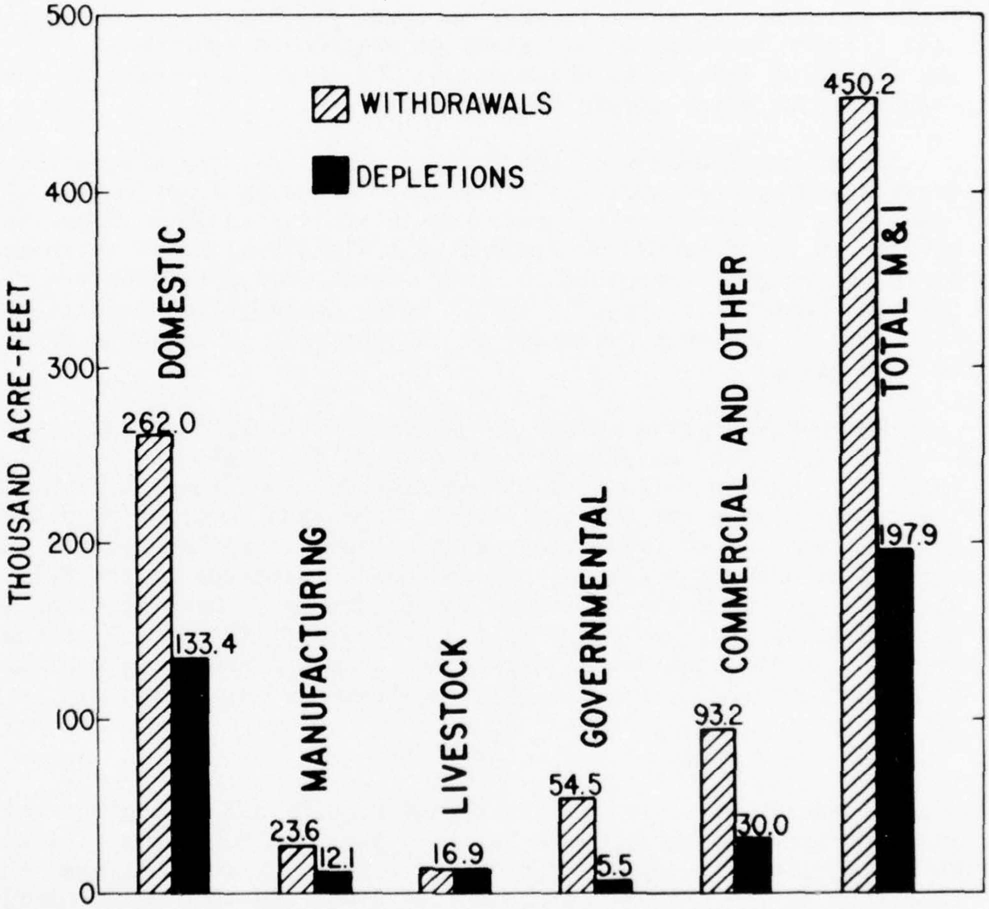
The uses of domestic water are very familiar and can generally be categorized as being exterior or interior uses. Exterior uses include lawn and plant watering, swimming pools and car washing. Interior uses include bathing, laundering, sanitation, dishwashing, garbage disposal operations, cooking and food preparation.

Most domestic uses of water do not have high consumptive requirements. The use of water for lawn and plant watering is an exception. Virtually all of the water used for lawn and plant watering is consumed which accounts for the large domestic per capita water depletion rate in the Region. Desert landscaping which could reduce the amount of water used in lawn and plant watering was not extensively used in 1965. The esthetic values of the regional population will have to change drastically before desert landscaping becomes important as a water conservation alternative.

Domestic air conditioning which relies upon the evaporation of water for cooling can have a high consumptive requirement. Economical developments in air conditioning technology have resulted in a significant amount of replacement of evaporative cooled equipment with refrigerant cooled equipment throughout the Region. The result has been a decrease in the consumptive use of water.

Domestic water requirements exhibit definite seasonal variations. Withdrawal requirements vary from a maximum during the summer months of about 170 percent of the average monthly requirement to a minimum during

FIGURE B-9
MUNICIPAL AND INDUSTRIAL WATER USE-1965



the winter months of about 40 percent of the average monthly requirement. Peak demands occur primarily during the months of June, July, and August.

Manufacturing

Manufacturing industries require water for a variety of uses including cooling, steam generation, process, sanitary and other water uses. Water for cooling and steam generation is required in most manufacturing industries and accounts for about 70 percent of the total manufacturing water use in the Region.

Water requirements of the manufacturing industry are met by withdrawals and by recirculation and reuse. Withdrawals by manufacturing industries in the Lower Colorado Region are increasing. There is, however, a trend toward decreasing unit withdrawal rates as indicated by the increasing recirculation ratio which was considerably higher than the national average in 1965. Water conservation measures are necessary in the Region because of the scarcity of adequate supplies in many areas.

The manufacturing demand for water does exhibit seasonal variations; however, seasonal patterns are not as predictable as for domestic water use. Some manufacturing industries require significant increases during the summer months for air conditioning and lawn watering purposes. Other manufacturing industries, such as some firms in the food and kindred products industries, require major increases in the fall months when raw food products are ready for processing. Manufacturing industry water demands vary generally from a maximum of 120 percent of the average monthly requirement during the summer months to a minimum of 80 percent of the average monthly requirements during the winter months.

Livestock

Livestock water requirements were significant throughout the Region with the largest requirements being in the Gila Subregion. Livestock water requirements depend upon climatic factors; species, age, and condition of the animal; nature of the diet; and upon water management practices. Virtually all of the water required for livestock purposes is consumed by the animals, by surface evaporation, or lost to seepage.

Livestock water requirements are seasonal in nature. Maximum water requirements generally occur during the month of August and amount to 125 percent of the average monthly requirement.

Governmental

Governmental water depletions were about 10 percent of governmental withdrawal requirements. The Gila Subregion had the largest governmental water requirements.

Governmental requirements for water result from a wide range of Federal, state, and local governmental activities. A variety of factors affects these requirements; climate is probably the most significant factor, and cost of water is the least significant. Some of the governmental uses of water include supplies for: public buildings such as post offices, schools, hospitals, and office buildings, military installations; watering public lawns, parks, and golf courses; fire control; street cleaning; public swimming pools; and various research activities. There are 8 military installations in the Region which have significant water requirements. Governmental water requirements are seasonal in nature and are greatest during the summer months.

Commercial and Other

The water depletions by commercial and other uses were about 32 percent of the withdrawal requirements. The Gila Subregion had the largest commercial and other water requirements.

Commercial requirements for water refer to the requirements of the trades and services industries. These requirements depend primarily upon two factors; per capita income in an area and the extent to which commercial services are provided for a transient rather than a permanent population. This latter factor is particularly relevant in the Lower Colorado Region because of the large tourist industry.

Commercial uses of water are varied and closely approximate the domestic uses of water. Commercial water uses exhibit seasonal variations with a maximum during the summer months of 120 to 180 percent of the average monthly withdrawal requirement. Minimum requirements during the winter months range from 50 to 80 percent of the average monthly withdrawal requirement.

Water requirements for the contract construction industry have been included in the commercial and other uses category. Water uses in the contract construction industry include dust control, batching of concrete, and various washing processes.

OUTDOOR RECREATION

Existing Development

The Federal Government, through several agencies, assists the states and other interests in the Region in providing outdoor recreation. There are more than 94 bureaus, independent offices, agencies, boards, commissions, committees, and councils presently involved with outdoor recreation, of which most are concerned with recreation in some form in the Lower Colorado Region. The existence of these programs blanketing the broad spectrum of Federal, state, and local agencies is probably responsible for the present status of outdoor recreation in the Lower Colorado Region.

The regional use of available outdoor recreation resources in 1965 ranged from the intensively developed and utilized city parks, such as Encanto Park in Phoenix, to undeveloped primitive areas typified by the Gila Wilderness of western New Mexico and the Mazatzal Wilderness area south of Payson, Arizona. All levels of government, and the private sector in some measure, provided recreation resources and recreation development for public enjoyment.

The Region, which comprises 90,327,000 acres including about 340,000 surface acres of water (at maximum storage pool), is largely owned or controlled by public agencies. Table B-9, Land Ownership and Administration - 1965, indicates the major land ownership divisions. The Bureau of Land Management and the Forest Service together, control about 80 percent of the Federal land holdings.

The lands available and suitable for outdoor recreation within the Region total about 68,000,000 acres and include private as well as public lands. Table B-21 indicates the distribution of recreation land by recreation land class for public agencies. Although private lands were not inventoried by recreation land class, a substantial amount (about 80 percent) of the total private land holdings is available to some degree for outdoor recreation purposes. Indian Trust lands, considered as private in this study, offered another potentially great recreation resource. Because much of the Indian Trust lands are in large blocks, it was assumed that most of the lands are similar in character to Recreation Class III lands. Recreation land classes, fully defined in Appendix XII, are as follows:

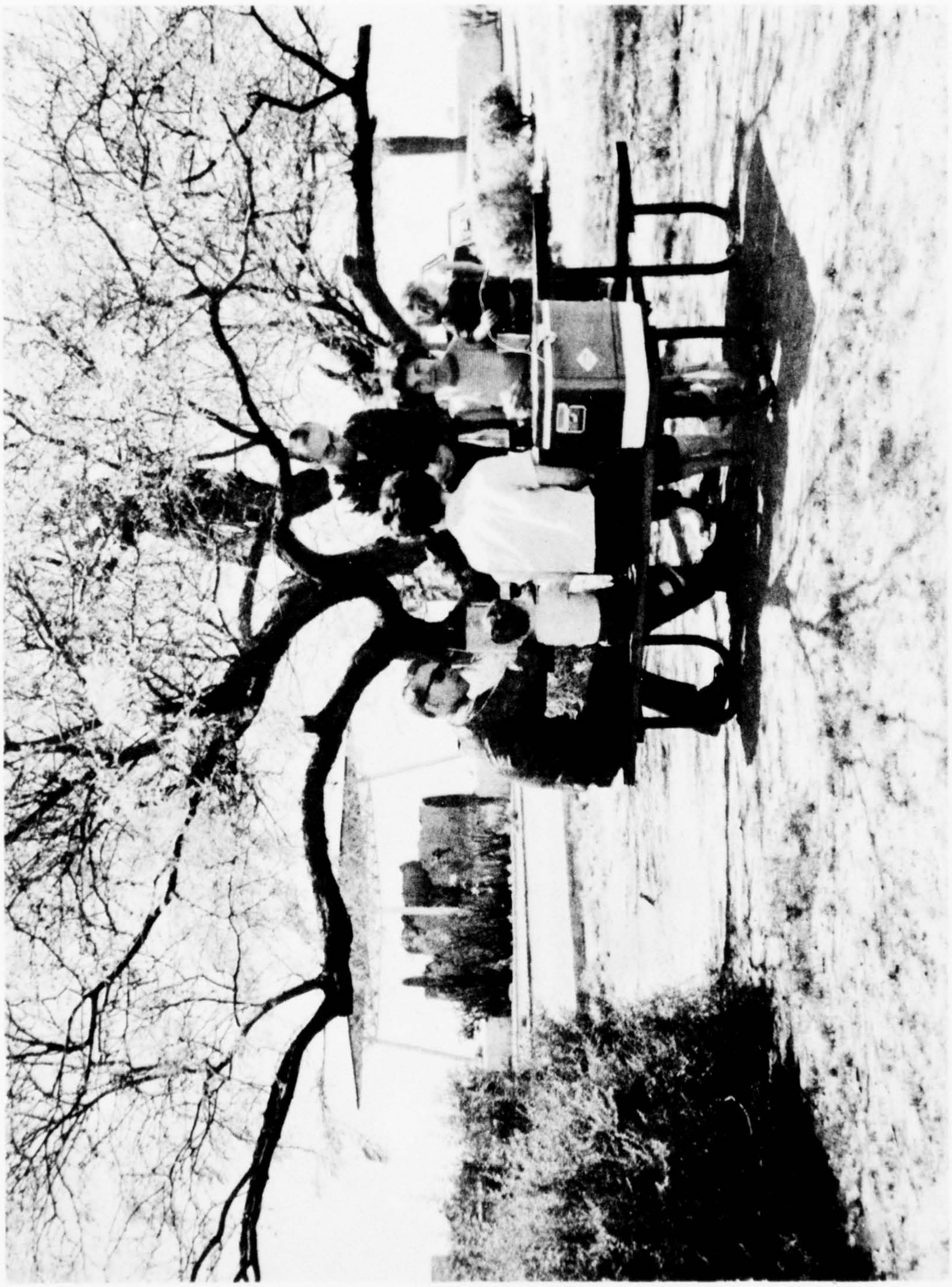
Class I - High Density Recreation Areas
Class II - General Outdoor Recreation Areas
Class III - Natural Environment Areas
Class IV - Outstanding Natural Areas
Class V - Primitive Areas
Class VI - Historic and Cultural Sites

Boating, skiing, swimming, and sunning are most popular on Lake Mead

Table B-21
Lower Colorado Region
Recreation Lands - 1965

ADMINISTRATION	LAND AREA (ACRES)						
Federal	Class I	Class II	Class III	Class IV	Class V	Class VI	Total
Forest Service	700	4,575	12,532,340	66,700	1,447,710	3,000	14,055,020
Bureau of Land Management	4,000	105,050	19,332,660	2,012,260	925,060	16,060	22,395,090
National Park Service	12,200	81,220	1,617,050	310,690	896,390	4,910	2,922,460
Fish and Wildlife Service	--	160	1,694,360	--	--	--	1,694,520
Total Federal (Available for Recreation)	16,900	191,005	35,176,410	2,389,650	3,269,160	23,970	41,067,090
Federal Land not Available for Recreation							5,768,410
State	--	3,570	213,290	4,090	9,500	40	230,490
Local 1/	4,390	7,960	50,960	10,340	76,500	910	151,060
Total Public (Available for Recreation)	21,290	202,535	35,440,660	2,404,080	3,355,160	24,920	41,448,640
Public Lands not Available for Recreation							16,035,360
Private							
Indian Trust 2/							15,549,700
Other Private 3/	20,808	17,339	10,665,784	69	0	0	10,704,000
Total Private (Available for Recreation)							26,253,700
Private Lands not Available for Recreation 4/							6,249,300
Total Region (Available for Recreation)							67,702,340
Region Lands not Available for Recreation							22,284,660

1/ Includes cities, counties, districts, etc.
2/ Not inventoried by Recreation Land Class.
3/ Rural Areas and Areas in Communities under 5,000 population.
4/ A portion of these lands may be available for recreation but have not been inventoried.
5/ May not agree with individual agency records because of the computer program used, lack of data, or time and money.



Picnicking--one of the most popular outdoor recreation activities

Picnicking site in the Saguaro National Monument

A shady campsite on the Lower Colorado River

PRESENT STATUS

At the Federal level, the Bureau of Land Management, the Forest Service, the National Park Service, and the Fish and Wildlife Service administered about 99 percent of public lands available and suitable for outdoor recreation in 1965. Typical of Bureau of Land Management developed recreation areas are the Cerbat Mountains Area and the Hualapai Mountain Complex.

The percentage breakdown of public land holdings, consisting of 61 percent of the total land available for recreation in the Region, by agency, is as follows:

Bureau of Land Management	54.0%
United States Forest Service	33.9%
National Park Service	7.1%
Fish and Wildlife Service	4.1%
State	0.6%
Local	0.3%

Saddle Mountain, west of Phoenix, attracts rockhounds because of the fire agate found in the area. Many other rockhounding areas can be found on public domain lands. Since much of the public domain lands are lowland and desert, these lands are used for camping, sightseeing, etc., during the fall, winter, and spring when the high country climate is not inviting for these activities.

Ten National Forests provided lands for outdoor recreation in 1965. The major winter sports areas are within National Forests. Charleston Peak near Las Vegas, Nevada, and Arizona Snow Bowl and Williams Ski Area near Flagstaff and Williams, Arizona, are heavily-used winter sports areas. In the summer when the desert temperatures rise, Forest Service campgrounds located at higher elevations are used to capacity.

Twenty-one areas in the Region are administered by the National Park Service. The areas include parks, monuments, and recreation areas. Zion National Park in Utah; and Grand Canyon National Park, Saguaro National Monument and Organ Pipe Cactus National Monument in Arizona are examples of the scenic splendor available. Coronado National Monument in Arizona and Gila Cliff Dwellings National Monument in New Mexico are preserved as historical monuments. Lake Mead National Recreation Area, which includes Lake Mead with 162,700 surface acres, and Lake Mohave with 28,200 surface acres, was visited by over 3½ million people in 1965. Campgrounds, boat ramps and marinas, picnic areas, and trails are some of the many facilities available for recreation use. within the Lake Mead National Recreation Area.

Typical state parks include the 18,000 acre Valley of Fire State Park, northeast of Las Vegas, Nevada, Buckskin Mountain State Park, along the Colorado River in Arizona, and Dixie State Park, in Utah. These and other state lands offer opportunities to enjoy land or water sports.

Although not an intensively developed area, South Mountain Park, part of the Phoenix park system containing more than 14,000 acres, is one of the world's largest city parks. Encanto Park, Phoenix; Randolph Park, Tucson; and Squires Park, Las Vegas, are examples of urban parks providing day-use recreation opportunity. The Maricopa County Park System in Arizona contains more than 60,000 acres in 20 separate areas, many of which were undeveloped in 1965.

Six designated wilderness areas and seven primitive areas are located within the Region and all but one lie within the Gila Subregion. These 13 areas encompass 1,447,000 acres. The Superstition Mountain Wilderness Area lies within a two-hour drive for almost 50 percent of the Region's population.

The total listing of existing recreation supply includes numerous smaller, specific recreation areas aggregating to a substantial base in terms of recreation days and acres.

Private recreation areas include golf courses, dude ranches, summer homes, racetracks, amusement parks and hunting and fishing preserves. The Indian Trust lands amount to 22 percent of the land available and suitable for recreation in the Region. The Fort Apache Indian Reservation and the San Carlos Indian Reservation, for example, have developed some of their lands for public recreation use. Special licenses and/or permits obtained from the reservation have enabled the Indians to make a profit from their lands while making more land available for public outdoor recreation enjoyment.

Water has a magnetic attraction to recreationists and, if available, will be used irrespective of location. In the Lower Colorado Region, it was estimated that about 218,700 surface acres of water were available for recreation use in 1965. At large reservoirs, such as Lake Mead and Lake Mohave, a recreation pool size rather than a full pool was used to arrive at water acreage availability. The regional distribution of impounded water available for recreation use is presented in Table B-22.

As can be seen from the table, the Colorado River with its many impoundments provides nearly 75 percent of the opportunity for recreation participation in water-based and water-related recreation activities. The most visited impoundments are Lake Mead, Lake Mohave, Lake Havasu, and Imperial Reservoir.

In the Gila Subregion, Bartlett and Horseshoe Lakes, on the Verde River; and Roosevelt, Apache, Canyon, and Saguaro Lakes, on the Salt River; Lake Pleasant, on the Agua Fria River; and San Carlos Reservoir on the Gila River provide most of the water area for water-based recreation.

Figure B-10 shows the percent distribution of recreation land and water acreage by subregion.

Table B-22
Distribution of Water Available for Recreation
Lower Colorado Region

Unit: Acres

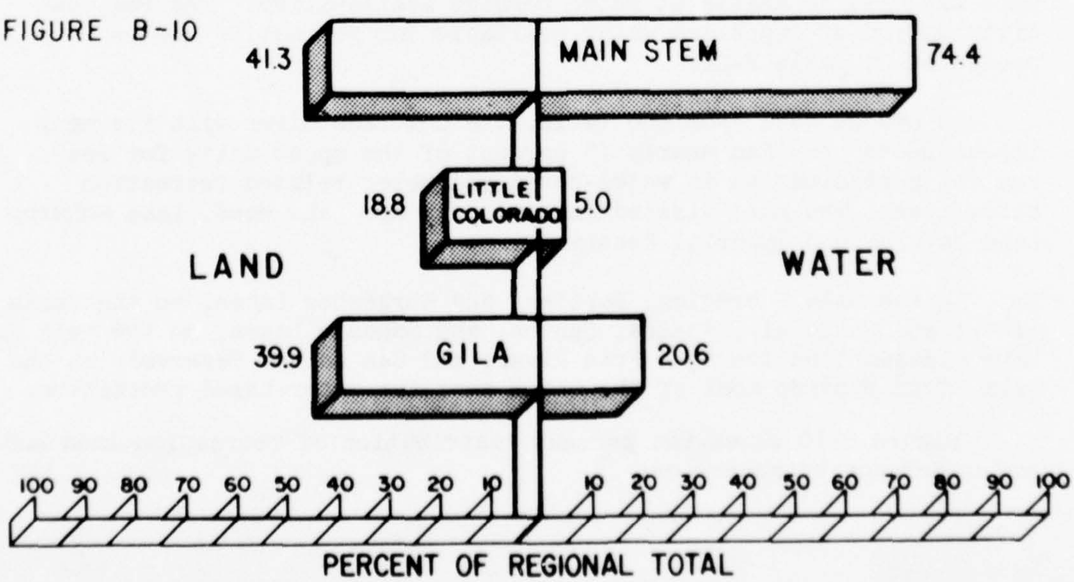
Location	Surface Area
Lower Main Stem Subregion	162,790
Little Colorado Subregion	10,840
Gila Subregion	45,040
Total Region	218,670

In the Little Colorado Subregion, many small lakes along the north slope of the Mogollon Rim provide for fishing and other water-based and water-related recreation. Near Flagstaff, Arizona, Lake Mary, Ashurst Lake and many other small lakes make this a summer mecca for recreationists escaping the desert heat. Although there are no large reservoirs or lakes in the Little Colorado Subregion, almost 84 percent of the water surface area in that Subregion is available for recreation purposes.

In addition to impoundments of the Region, many streams, such as portions of the Colorado, Gila, Salt and Verde Rivers, provide recreation opportunities.

Thus, it appears that the total recreation water supply for the 1965 base year was adequate though, in some respects, not ideally distributed.

FIGURE B-10



FISH AND WILDLIFE

Fish

About 85 species of fish are known to exist in the Lower Colorado Region. Approximately 25 species provide sport fishing and the others have value as forage fish, as pollution indicators, for scientific investigations, and as a source for a possible commercial fishery. Fifty-six species of fish have been introduced. The notable introductions of fish are cold water species of grayling and northern pike and warm water species including striped bass, white bass, channel catfish, flathead catfish, yellow perch, walleye, tilapia, and threadfin shad. White sturgeon, Kokanee, and silver salmon have been introduced in Lake Mohave on the Colorado River. Native species have not provided any important sport or commercial fishing in the Region for many decades. The Gila and Apache trout are considered endangered species. Important species of bait fish such as the redshiner, fathead minnow, speckled dace, redside shiner, and threadfin shad are found regionwide in most streams and lakes.

Fishing waters in the Lower Colorado Region consist of approximately 251,000 acres of streams and manmade impoundments. There are no natural lakes of importance to fishing. The fishery is classified into two major categories: the cold water trout fishery of headwaters and impoundments generally above 5500 feet elevation; and the warm water "spiny-rayed" fishery in the streams and impoundments of elevations below 6000 feet elevation. The waters of the Colorado River and other streams in the Region that are stocked and provide trout fishing only during the cooler months of the year are classed as warm water fisheries. Table B-23 shows cold and warm water habitat available in 1965 by subregion.

In 1965, there were 4,217,000 fisherman-days expended in the Lower Colorado Region. Based on the hydrologic Region's population of approximately 1,847,000, the annual use of the fishery resources was about 2.3 man-days per capita. Over 52 percent of the total fishing in the Region occurred in the Lower Main Stem Subregion. The second most fished subregion is the Gila, in which 40 percent of the total fishing occurred. The Little Colorado Subregion provided 8 percent of the total fishing in the Region.

Sixty-seven percent of the fishing in the Region was in impoundments and 33 percent was in streams. Warm water impoundments supported 49 percent of the total fishing compared to 18 percent from cold water impoundments. Warm water streams provided 23 percent of the total fishing as compared to 10 percent provided by cold water streams. Table B-24 shows man-days of fishing spent annually in the Region.

Map of fish and wildlife facilities existing in 1965 follows page 98.

Table B-23
Fish Habitat: Cold and Warm Water 1/ - 1965
Lower Colorado Region

Unit: Acres

Hydrologic Subregion	Streams		Impoundments 2/		Subtotal		Total
	Cold Water	Warm Water	Cold Water	Warm Water	Cold Water	Warm Water	
Lower Main Stem 3/	294	6,215	1,753	212,487	2,047	218,702	220,749
Little Colorado	188	11	2,401	2,162	2,589	2,173	4,762
Gila	1,483	2,007	3,013	19,060	4,496	21,067	25,563
Regional Total	1,965	8,233	7,167	233,709	9,132	241,942	251,074

1/ Habitat includes all waters in the Region supporting fish populations. Cold water: Waters generally above 5500 feet elevation that provide year-around trout fishing. Warm water: Waters generally below 6000 feet elevation that provide fishing for such species as largemouth bass, bluegill, and catfish.

2/ Impoundments include the relatively small acreages of farm and ranch ponds.

3/ Acreages include the California side of the Colorado River and impoundments from Davis Dam downstream to the International border.

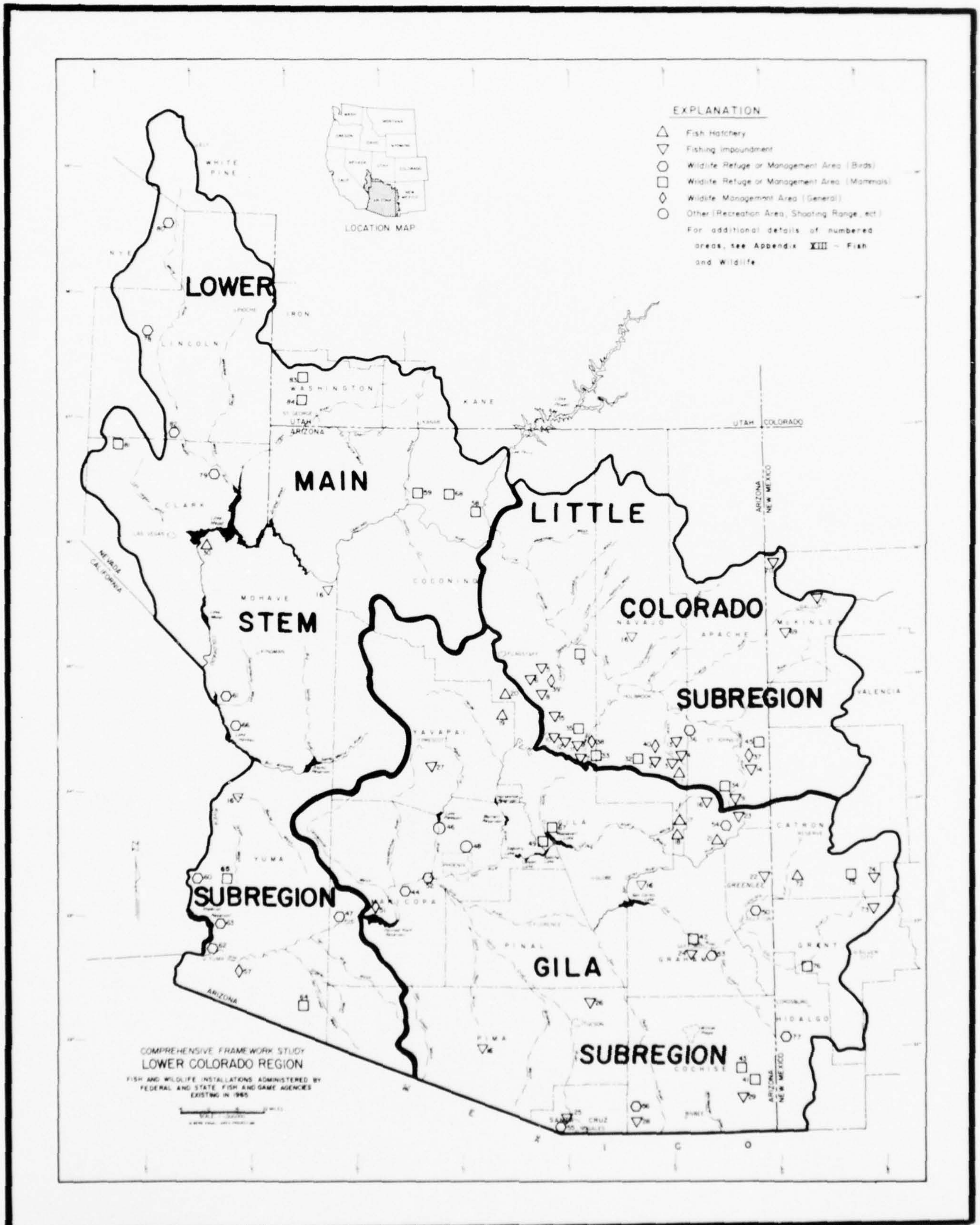

EXPLANATION
Fish Hatchery
Fishing Impoundment
Wildlife Refuge or Management Area (Birds)
Wildlife Refuge or Management Area (Mammals)
Wildlife Management Area (General)
Other (Recreation Area, Shooting Range, ect)
For additional details of numbered areas, see Appendix XIII - Fish and Wildlife
LOCATION MAP
LOWER
MAIN
STEM
SUBREGION
LITTLE
COLORADO
SUBREGION
GILA
SUBREGION
UTAH
ARIZONA
UTAH COLORADO
ARIZONA NEW MEXICO
NEVADA CALIFORNIA
ARIZONA
WHITE PINE
NYE
LINCOLN
IRON
WASHINGTON
KANE
CLARK
MOHAVE
COCONINO
NAVAJO
APACHE
MCKINLEY
VALENCIA
YAVAPAI
GILA
CATRON
YUMA
GREENLEE
GRANT
PINAL
HIDALGO
PIMA
COCHISE
SANTA CRUZ
COMPREHENSIVE FRAMEWORK STUDY
LOWER COLORADO REGION
FISH AND WILDLIFE INSTALLATIONS ADMINISTERED BY FEDERAL AND STATE FISH AND GAME AGENCIES EXISTING IN 1965

Table B-24
Sport Fishing: Cold and Warm Water - 1965 1/
Lower Colorado Region

Unit: 1,000 Fishing Man-days

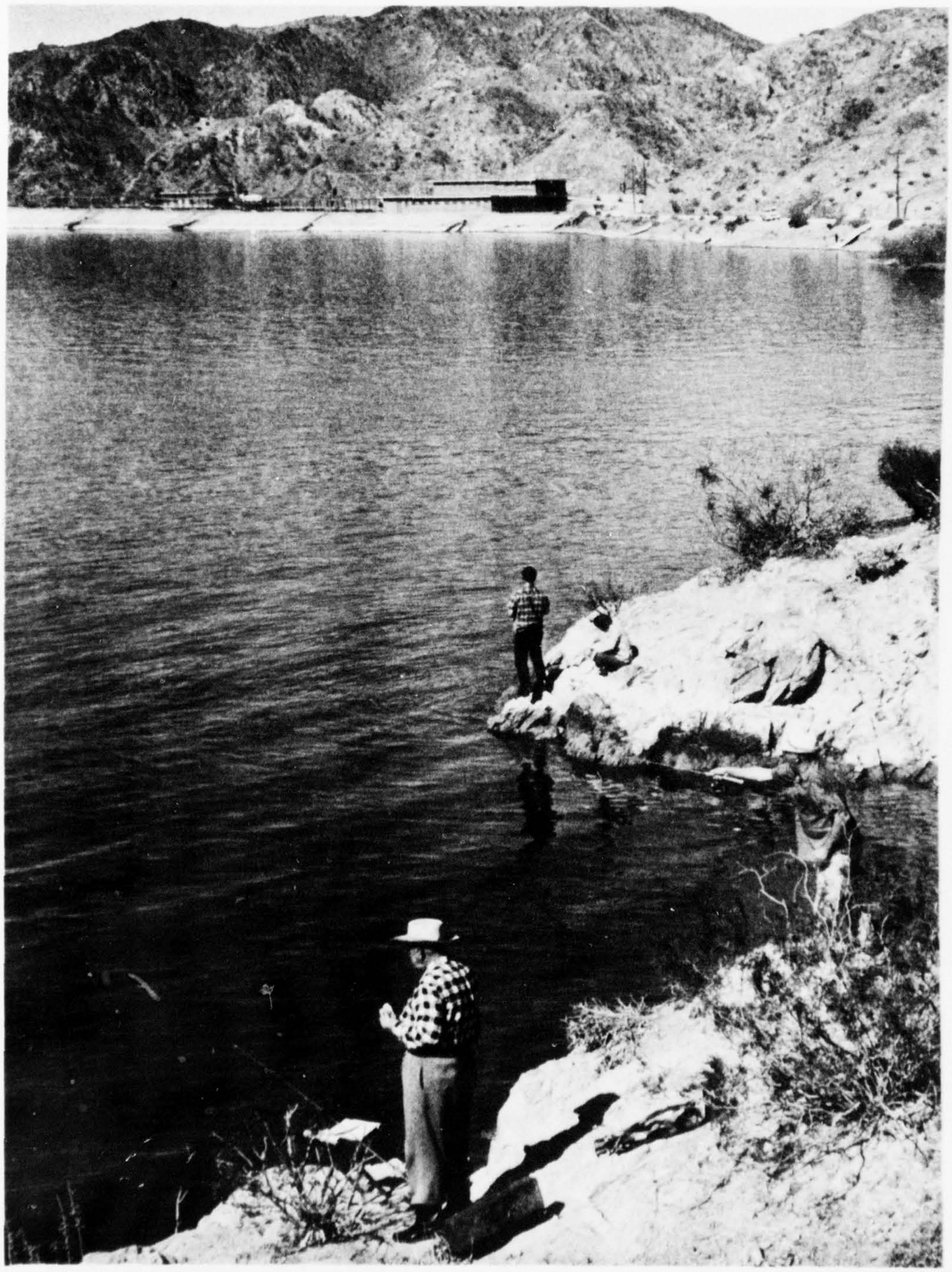
Hydrologic Subregion	Streams		Impoundments 2/		Subtotal		Total
	Cold Water	Warm Water	Cold Water	Warm Water	Cold Water	Warm Water	
Lower Main Stem 2/	189.9	640.8	204.9	1,189.0	394.8	1,829.8	2,224.6 2/
Little Colorado	27.3	1.6	213.4	103.7	240.7	105.3	346.0
Gila	219.1	315.1	349.1	763.1	568.2	1,078.2	1,646.4
Regional Total	436.3	957.5	767.4	2,055.8	1,203.7	3,013.3	4,217.0

1/ Approximately 75 percent of the cold water fishing man-days was expended in "Warm Water" habitat.

2/ An additional 6.0 man-days of cold water fishing and 604.0 man-days of warm water fishing are expended on the California side of the Colorado River from Davis Dam downstream to the International border.

Fishing deep water upstream from Hoover Dam

Success on Roosevelt Lake on the Salt River in Arizona.



Trout fishing on Lake Mohave--Federal Fish Hatchery in background supplies 150,000 pounds of stock fish annually

Javelina

Wildlife (Desert Bighorn Sheep)

PRESENT STATUS

The fisherman-days used in 1965 were estimated to be nearly 75 percent of the Region's capacity of 5,723,000 man-days. The available warm water habitat was being fished to 67 percent of its potential. Only an insignificant amount of cold water habitat is not being used to its capacity.

Although the overall supply of warm water sport fishing in the Region presently appears adequate, many factors tend to discourage use or limit realization of the available capacity. Poor distribution of the supply relative to demand is the most important factor limiting full use of the capacity. Sheer magnitude of the demands generated by the population centers causes severe localized demand-supply problems. Demand varies directly with human population, and good quality fishing opportunities vary inversely with the population.

Sport fishery installations and facilities existing in the Lower Colorado Region in 1965 consisted of 97 fishing lakes and 8 fish hatcheries. There were 3 national fish hatcheries and 5 state fish hatcheries that produced approximately 6,700,000 fish, all of which were trout with the exception of 150,000 channel catfish. The Region's production was about 80 percent of the total fish stocked. The remaining 20 percent of the fish stocked were imported from outside the Region.

The primary-purpose public fishing lakes existing in 1965 provided about 6,400 acres of water for fishing. These lakes were constructed and managed primarily for fishing and use of the water surface was so restricted. Nineteen of the lakes, totaling about 1,400 acres, are adminstered by state fish and game agencies. Four lakes, providing 850 acres, are administered jointly by State-Federal agencies. Two private lakes, providing 140 acres of water surface, were open to the public and managed by the Arizona Game and Fish Department. Indian Tribes administered 72 fishing lakes providing about 4,000 acres of water in 1965.

Consumptive use of water by fish hatcheries and impoundments designed for fish is generally minor. In 1965, approximately 10,315 acre-feet of water were consumptively used. In addition to 6,400 surface acres of water, approximately 425 acres of land were utilized for hatchery facilities and fisherman access. Table B-25 shows land and water needed in 1965 to maintain fish facilities in each subregion.

Table B-25
Land and Water Requirements for Fishery Facilities 1/ - 1965
Lower Colorado Region

Hydrologic Subregion	Land Acres	Water Acres	Water Nonconsumptive 2/ (Acre-Feet)	Water Consumptive 3/ (Acre-Feet)
Lower Main Stem	5	300	30,000	15
Little Colorado	45	2,500	6,000	4,300
Gila	375	3,600	50,000	6,000
Regional Total	425	6,400	86,000	10,315

1/ Fish hatcheries and primary-purpose fishing lakes.
2/ Water diverted.
3/ Water consumed, based on established water rights.

Commercial fishing is of minor importance in the Region. Although commercial fishing has been conducted on a sporadic basis for a number of years, there are few records of commercial catches prior to 1965. Since 1960, the Region's total catch of commercial food-fishes, consisting mostly of buffalo-fishes, have been taken from Roosevelt and Apache Lakes on the Salt River in central Arizona. Annual harvest from these lakes in the period 1963-1968 ranged between 17,640 and 33,075 pounds.

The only recorded fishing for bait fish from wild sources is from the Utah portion of the Region, and the catch in 1965 was nearly 250 pounds. The value of the catch, which was sold to fishermen, was approximately $1,200. In 1965, private enterprises recorded rearing 2,500 pounds of bait-fish valued at $13,000 retail and 57,500 pounds of rainbow trout with an estimated market value of $50,000.

Wildlife

Wildlife species in the Lower Colorado Region are as many and varied as the climate, terrain, and vegetative types. More than 40 species of wildlife provide hunting ranging from highly prized bighorn sheep and elk to hunting of rabbits and coyotes. There are also many species of small mammals and birds, which provide enjoyment for the nonhunting outdoorsman in nature study and photography.

In relation to hunting, there are three wildlife types--big game, upland game (including fur animals and nongame species), and waterfowl.

PRESENT STATUS

Big Game

Big game species are distributed nearly regionwide throughout approximately 72 million acres of widely diverse habitat types. Deer are the most abundant of the big game species and have a range of about 70 million acres. Somewhat more limited in range than deer, but still an important big game species, are elk which occupy over 6 million acres of habitat in the higher country along the Mogollon Rim. Pronghorn antelope occurring in somewhat greater numbers than the elk occupy nearly 10 million acres of the rolling grassland, both north and south of the Mogollon Rim. The desert bighorn sheep, although its numbers are limited, is one of the most desirable big game trophies of the Region and occurs on nearly 40 million acres of the low desert mountain ranges in southern Nevada and the southern and western portions of Arizona.

The black bear ranges on about 9 million acres throughout much of the Region's pine forests and the pinyon-juniper and oak country along the Mogollon Rim. Wild turkey is considered big game and ranges throughout about 12 million acres in approximately the same area as the black bear.

The javelina, or collared peccary, ranges over 36 million acres in areas varying from the lower pinyon-juniper into the higher southern desert shrub areas. The American Bison or buffalo, now extinct throughout most of its former range, is found on approximately 61,000 acres in special areas set aside especially for its preservation.

Upland Game

Upland game species vary widely in the extent of their range, some extending nearly throughout the Region while others are quite localized in distribution. Examples of these wide variations of distribution include the mourning dove and cottontail rabbit with nearly a regionwide distribution of 90 million acres. The white-winged dove is more restricted in distribution, occuring on almost 21 million acres in the lower desert regions of western Arizona and southern Nevada. The bandtail pigeon occupies over 14 million acres of range in the central to southeastern portion of the Region. Even more limited in distribution are the blue grouse, chukar, and sage grouse with a range of 1.3 million, 68,000 and 17,000 acres, respectively.

Three species of quail--Gambel's, Mearn's, and Scaled--occur in the Region. The Gambel's quail occupies an area of approximately 13 million acres primarily in the desert and lower mountain elevations. Mearn's and Scaled quail normally occur at higher elevations than Gambel's quail, and occupy approximately 12 and 11 million acres, respectively.

The Afghan white-winged pheasant recently has been stocked in agricultural areas in the desert, and presently occupies approximately

292,000 acres of suitable habitat. The ringnecked pheasant is found in the Region, but its range is quite limited.

Pine forests are the preferred habitat for the Abert's squirrel, which occupies approximately 6 million acres of habitat. Several species of fur animals and nongame species occur throughout the Region and provide considerable hunting and trapping recreation. Taking of fur animals for commercial purposes is insignificant in amount.

Waterfowl Habitat

Waterfowl habitat within the Region consists of approximately 42,000 acres of native habitat along the permanent streams, manmade lakes and marsh habitat.

Hunter Use

In 1965, there were 1,343,500 man-days of hunting expended in the Lower Colorado Region. Based on the hydrologic region's population of approximately 1,847,000, hunter use of the wildlife resources of the hydrologic region amounted to 0.73 man-days per capita. Upland game hunting which includes sport hunting for fur animals and nongame animals was the most popular in the Region, accounting for 56 percent of all hunting. Big game hunting accounted for 39 percent and waterfowl accounted for the remaining 5 percent of the hunting in the Region.

The Lower Main Stem Subregion, second in popularity with the hunting public, had some of the best bighorn sheep habitat as well as much of the white-winged dove and waterfowl habitat. On a regional basis in 1965, this Subregion accounted for 20 percent of the total hunting; 25 percent of the big-game hunting; 15 percent of the small-game hunting; and 32 percent of the waterfowl hunting.

The Little Colorado Subregion contained some of the Region's better pronghorn antelope habitat and a considerable amount of good elk and mourning dove habitat. In 1965, this Subregion accounted for 11 percent of the total regional hunting; 14 percent of the big game hunting; 8 percent of the upland game hunting; and 10 percent of the waterfowl hunting.

The Gila Subregion contained the widest range of wildlife habitat types, as well as some of the largest expanses of the better habitat types in the Region. This Subregion also contained approximately 75 percent of the regional population in 1965. As a result, the Gila Subregion sustained 69 percent of the total regional hunting. This hunting consisted of about 61 percent of the big game hunting; 77 percent of the upland game hunting, and 58 percent of the waterfowl hunting in the Region.

Table B-26 gives a breakdown of the distribution of sport hunting in the Lower Colorado Region.

Table B-26
Sport Hunting - 1965
Lower Colorado Region

Unit: 1,000 Man-days

Subregion	Big Game	Upland Game	Waterfowl	Total
Lower Main Stem	129.6	112.6	23.6	265.8
Little Colorado	76.1	61.5	7.4	145.0
Gila	316.3	574.0	42.4	932.7
Region	522.0	748.1	73.4	1,343.5

Hunter use of the wildlife resource in 1965 was estimated as approximately 53 percent of the total resource capacity. Although the total wildlife resource created the appearance of being sufficient to supply the needs; the apparent abundance occurred, however, relative only to certain species. Upland game resources were heavily hunted in some areas while other areas remained relatively untouched. The rugged terrain of the Region, while creating a natural refuge for wildlife in many areas, in itself was a limiting factor in the hunting of game. Legal right of access, in some cases, also limited utilization of wildlife resources.

Designated wildlife developments and facilities managed intensively for wildlife production in 1965 included 49 multiple- and primary-use management areas, 568 habitat improvement facilities, and 20 access roads comprising a total of about 4.2 million acres. Nineteen of the management areas were primarily for big game; 7 areas were for small game; 17 areas were for the protection of waterfowl; and 5 areas were for wildlife in general and associated activities.

The management of lands for big game and small game does not require significant amounts of water. Water catchments developed for these species are small and are normally constructed in such a manner as to reduce evaporation. A total of approximately 1,000 acre-feet of water is consumed at the existing water catchments.

There are, however, an estimated 34,300 surface acres of water which have been developed in conjunction with waterfowl management in the Region. These waterfowl areas require impounded water for lake and marsh development and maintenance. Water also is required to irrigate areas for waterfowl use and provide seasonal water service areas for waterfowl. In 1965, nearly 100,000 acre-feet of water were consumptively used on wildlife management areas mostly in the Lower Main Stem Subregion.

Water consumption for wildlife management areas in the Gila and Little Colorado Subregions was insignificant in 1965.

Table B-27 shows the estimated land and water requirements of the wildlife developments and facilities which were in existence in 1965.

Table B-27
Land and Water Requirements for Wildlife Facilities 1/ - 1965
Lower Colorado Region

Subregion	Land Acres	Water Diversion 1/ (Acre-Feet)	Water Consumptive Use (Acre-Feet)
Lower Main Stem	4,037,000	110,000	100,000
Little Colorado	16,000	2/	2/
Gila	137,000	2/	2/
Region	4,190,000	110,000	100,000

1/ Consumptive water requirement.
2/ Less than 100 acre-feet.

Trapping for fur animals for commercial purposes is insignificant in the Region. Some furs, consisting primarily of the predatory fur animal species such as coyote, bobcat, and fox were taken by sport hunters. Thus, fur marketing was a byproduct of sport hunting. The total furs taken in 1965 consisted of 4,900 pelts, valued at $12,000.

ELECTRIC POWER REQUIREMENTS

Historical

Electric power requirements in the Region increased rapidly during the period 1955 through 1965. Average annual growth rate was 9.5 percent which is much greater than the national growth rate of 6.6 percent for this period. Annual past power requirements for 1955, 1960, and 1965 are shown in Table B-28.

Table B-28
Annual Past Power Requirements 1/
Lower Colorado Region

Year	Energy Gigawatt Hours	Peak Megawatt	Load Factor Percent	Month of Peak
1955	5,387	1,082	56.8	Sept.
1960	8,967	1,798	56.9	July
1965	13,346	2,695	56.5	Aug.

1/ Quantities partially estimated.

The occurrence of peak loads in summer months is attributable to air conditioning and irrigation pumping requirements due to the desert climate of the Region.

Energy Loads by Consumer Classification

The rate of increase in residential use was greater than that of the other classifications. This resulted more from increased use per customer rather than from the increased number of customers. Commercial use had the next greatest rate of increase based on a similar condition. Although irrigation energy use has shown a net increase, it has dropped from 28.9 percent of total sales to 13.3 percent in the 1955-1965 decade. Table B-29 compares the 1955-1965 average annual growth rate for three principal classifications of energy usage for the Region and for the United States.

Table B-29
Growth of Electrical Energy Uses,
By Consumer Classification - 1955-1965
Lower Colorado Region

Unit: Percent

	1955-1965 Growth Rates	
	Lower Colorado Region	United States
Residential 1/	13.4	8.4
Commercial	11.9	8.9
Industrial	10.5	5.4

1/ Includes farm and nonfarm but excludes irrigation and drainage pumping.

Table B-30 shows the regional distribution of energy sales to principal consumer use classifications and transmission losses.

Power Resources Existing and Under Construction

Electric utility generating capacity installed and under construction in the late 1960's in the Region amounts to 4,310,863 kw. The total includes 14 hydroelectric plants with installed capacity of 1,655,000 kw, 17 steam-electric plants with 2,534,668 kw, and 16 internal-combustion electric plants with 121,195 kw installed. Table B-31 shows installed capacity in the Region during 1965.

Hydroelectric Power

The primary purpose of water resource projects in the Lower Colorado Region is to provide water for municipal, industrial, and agricultural purposes and/or to provide flood control. Hydroelectric power is often a byproduct of these multipurpose reservoir projects.

Existing hydroelectric power developments in the Lower Colorado Region had an installed capacity of 1,655 mw after deduction for scheduled retirements. There were no hydroelectric projects under construction in 1965.

The first units at Hoover Dam were completed in 1936 and the last in 1961. In 1965, it was the third largest hydroelectric plant in the United States with an installed capacity of 1,340 mw and an average annual output of more than 4 terawatt-hours.

Table B-30
Distribution of Energy Sales and Losses - (1955-1965)
Lower Colorado Region

Item	1955		1960		1965	
	Energy (gwh)	Percent of Utility Sales (%)	Energy (gwh)	Percent of Utility Sales (%)	Energy (gwh)	Percent of Utility Sales (%)
Residential Farm and Non-farm	918	19.4	1,809	22.5	3,251	27.5
Irrigation and Drainage Pumping	1,368	28.9	1,705	21.2	1,572	13.3
Commercial	1,027	21.7	1,922	23.9	3,180	26.9
Industrial	1,288	27.2	2,397	29.8	3,511	29.7
Street and Highway Lighting	57	1.2	72	0.9	106	0.9
All Other	76	1.6	137	1.7	201	1.7
Subtotal--Consumer Use	4,734	100.0	8,042	100.0	11,821	100.0
Transmission Losses	653	13.8	925	11.5	1,525	12.9
Total Requirements	5,387	113.8	8,967	111.5	13,346	112.9

Table B-31
Summary of Installed Capacity-Electric Power Resources - 1965
Lower Colorado Region

Units: (kw)

Subregion	Installed Capacity 12/31/65	Under Construction (After 12/31/65)	Scheduled Retirement (After 12/31/65)	No. of Plants	Net Total
		Hydroelectric			
1	1,568,310	0		6	1,568,310
2	0	0		0	0
3	87,490	0	(800)	8	86,690
All	1,655,800	0	(800	14	1,655,000
		Steam-electric			
1	460,516	113,636	0	4	574,152
2	131,100	0	0	2	131,100
3	1,657,480	173,300	(1,364	11	1,829,416
All	2,249,096	286,936	(1,364)	17	2,534,668
		Internal-combustion			
1	52,128	1,136	(1,380)	5	51,884
2	0	0	0	0	0
3	75,046	1,910	(7,645)	11	69,311
All	127,174	3,046	(9,025)	16	121,195
		Total Power Resources - All Types			
1	2,080,954	114,772	(1,380)	15	2,194,346
2	131,100	0	0	2	131,100
3	1,820,016	175,210	(9,809)	30	1,985,417
All	4,032,070	289,982	(11,189)	47	4,310,863

The 3 Federal plants--Davis, Coolidge, and Hoover--have a combined capacity of 1,575 mw, or 95.2 percent of the hydroelectric total, and 36.5 percent of the total electric utility generating capacity of all types for the Region. However, approximately 970 mw of the above-mentioned installed capacity are utilized to serve loads in the California Region.

Thermal-electric Power

Seventeen steam-electric plants,having a total of 2,535 mw installed capacity after deduction for scheduled retirements, were in operation in 1965. In addition, there were 16 internal-combustion plants having 121 mw of installed capacity. The largest existing steam-electric plant in the Region is the Salt River Project's Agua Fria plant, with an installed capacity of 390 mw. Tucson Gas and Electric Company's Irvington steam-electric plant is next in size, with 331 mw. The largest internal-combustion plant is Nevada Power Company's 30-mw-diesel plant in the Westside substation, Las Vegas, Nevada.

Utility companies having more than 100 mw of thermal capacity installed or under construction in 1965 are Arizona Public Service 796.9 mw; 1/ Tucson Gas and Electric, 609.0 mw; Salt River Project, 538.4 mw; and Nevada Power Company, 528.4 mw. Subsequently, since 1965 construction was started on the 1,580 mw Mohave plant in southern Nevada which will serve loads in southern California, southern Nevada, and central Arizona. This plant is scheduled to be completed in October 1971.

Electric Power Exchanges

Power exchanges to and from the Lower Colorado Region occur with the California, Great Basin, and Upper Colorado Regions, a part of Western New Mexico, Mexico, and the Federal Hydroelectric System of the Missouri River Basin. The exchanges with the Great Basin Region, the portion of New Mexico outside the Upper Colorado Region, and Mexico are minor amounts, and are not included with those listed in the following paragraph.

In 1966, major exchanges between organizations within the Lower Colorado Region and those outside the Region were as follows:

	Generating Capacity Noncoincident Peak (mw) 2/			Energy (gwh) 3/		
	In	Out	Net Out	In	Out	Net In
Summer	1,048	1,348	300	3,081	2,155	926
Winter	1,080	1,280	200	2,840	1,531	1,309

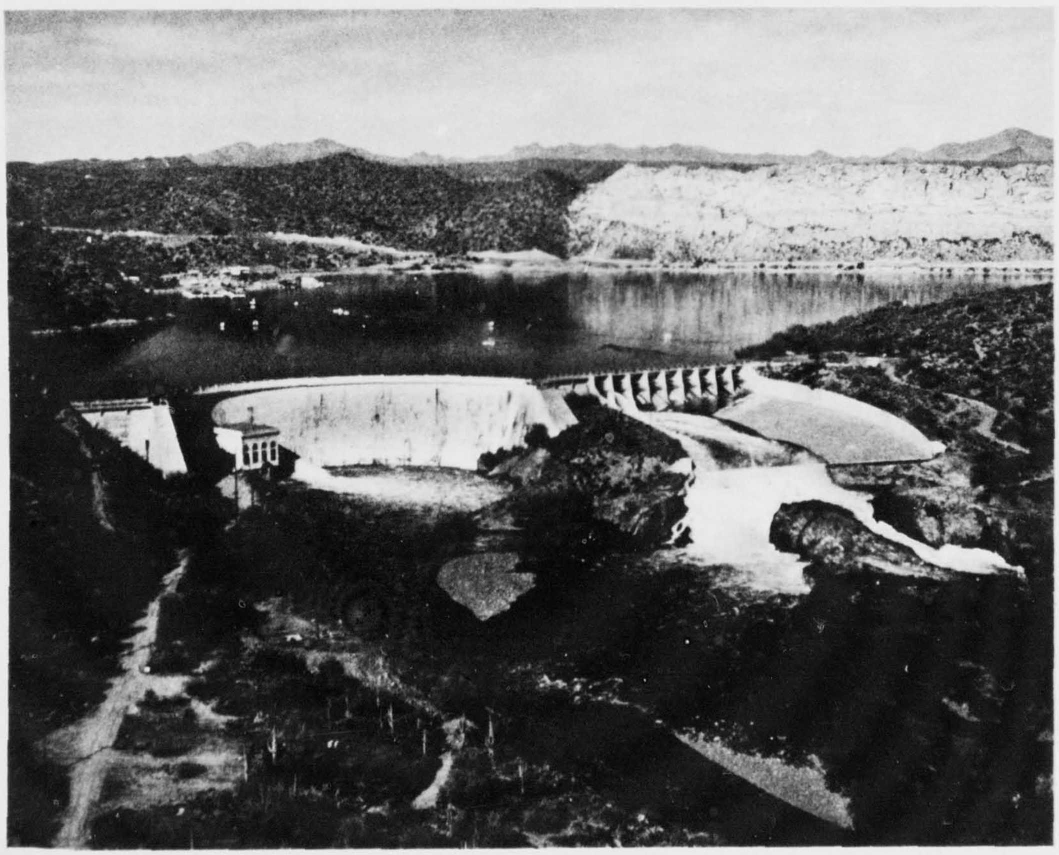
1/ Includes 75 mw Yuma Axis plant, which is jointly owned with Southern California Edison.

2/ Summer--July; Winter--December.

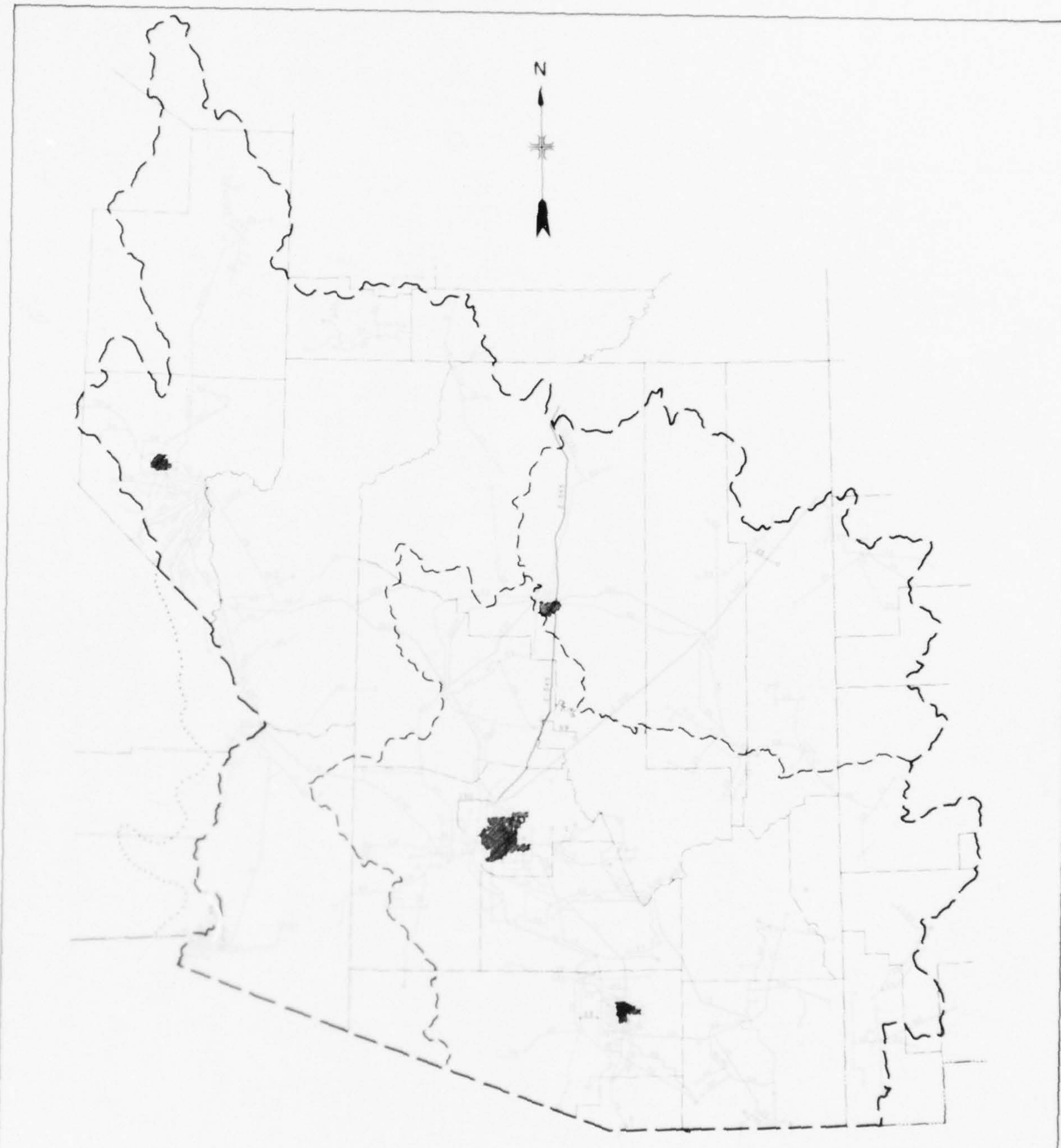
3/ Summer--April, May, June, July, August, and September.
Winter--January, February, March, October, November, and December

Industrial and Miscellaneous Power

Fourteen steamplants and 5 internal-combustion plants have a total installed capacity of 240 mw. All the industrial plants are thermal plants located in Arizona, most of which are owned by mining companies, particularly copper mining, and have a total installed capacity of 195 mw. The lumber industry operates four steamplants with 43 mw installed capacity.



Stewart Mountain Dam and Power Plant, Salt River, Arizona.



EXPLANATION

HYDRO POWER PLANT

FUEL POWER PLANT

SUBSTATION OR CITY

TRANSMISSION LINES

345 KV

230-287 KV

115-161 KV

69 KV

46 KV OR LESS

CONNECTING LINES

CROSS OVER LINES

UNDER CONSTRUCTION

NOTES:

1. TRANSMISSION LINES SIMPLIFIED IN CONGESTED AREAS.
2. POWER PLANTS UNDER 1,000 KW ARE NORMALLY NOT SHOWN.

COMPREHENSIVE FRAMEWORK STUDY

LOWER COLORADO REGION

PRINCIPAL ELECTRIC FACILITIES
JUNE 30, 1965

SCALE IN MILES

20 0 20 40 60 80

RESOURCES AVAILABILITY

CHAPTER C - RESOURCES AVAILABILITY

WATER

The Region is richly endowed with most natural resources, except water, needed to assist in meeting the demands of an increasing population. The climate, combined with available open space, is a strong attraction for immigration to the Region and is a stimulus for population and economic growth.

There are three sources of water supply presently available for use in the Lower Colorado Region: (1) a portion of Colorado River flows delivered at Lee Ferry, (2) local runoff originating within the regional boundaries, and (3) local ground water. Table C-1 summarizes the present and projected available water supply.

Colorado River

Flows originating in the Upper Colorado Region and released through Glen Canyon Dam constitute a major source of supply to the Lower Colorado Region. The release made in any single year depends on many variables. However, Article IIId of the Colorado River Compact provides that the river at Compact Point, 17 miles downstream from Glen Canyon Dam, will not be depleted below an aggregate of 75 million acre-feet for any period of 10 consecutive water years. If sufficient Colorado River main stem water is available for release to satisfy 7,500,000 acre-feet of annual consumptive use in the three Lower Colorado River Basin States, Arizona, Nevada, and California are apportioned 2,800,000, 300,000, and 4,400,000 acre-feet, respectively.

The Mexican Treaty of 1944 provides for delivery of 1,500,000 acre-feet of water annually to Mexico. The Colorado River Compact provides for the sharing, by the Upper and Lower Basins, of any burden which might arise because of the water treaty with Mexico. The Mexican Treaty provides that in the event of extraordinary drought, deliveries to Mexico may be reduced in the same proportion as consumptive uses in the United States are reduced.

The average annual undepleted flow of the Colorado River as it enters the Lower Colorado Region is estimated at about 15.09 million acre-feet for the 60-year period 1906-65. In its natural state, the river would gain an average of about 1 million acre-feet of water during its journey through the canyons to the site of Hoover Dam then lose more than the million acre-feet gained in the upper reaches as the river continues its course toward the Gulf of California. With the contribution of the Gila River near the Mexican Border, the Colorado River's average annual undepleted flow into Mexico would be about 15.9 million acre-feet.

Table C-1
Present and Projected Available Water Supply
Lower Colorado Region

Unit: Million Acre-Feet

	1965	1980	2000	2020
Colorado River (1906-65) 1/				
Modified Flow, Compact Point	11.64	10.26	8.97	8.54
Estimated System Spill 2/	- 0.65	- 0.52	- 0.15	- 0.15
Main Stem Reservoir and Channel Losses	- 1.86	- 1.59	- 1.59	- 1.59
Net Available in the River	9.13	8.15	7.23	6.80
Out of Region Depletions	- 6.50	- 5.90	- 5.90	- 5.90
California	(5.00)	(4.40)	(4.40)	(4.40)
Mexican Treaty	(1.50)	(1.50)	(1.50)	(1.50)
Colorado River Water Available to Lower Colorado Region	2.63	2.25	1.33	0.90
Local Water Supply	3.12	3.12	3.12	3.12
Total Water Supply Available to Lower Colorado Region	5.75	5.37	4.45	4.02

1/ From Appendix V, Water Resources, Comprehensive Framework Studies, Lower Colorado Region, June 1971.

2/ From Lower Colorado River Basin Operation Studies--90th Congress, Second Session, House of Representatives, Serial No. 90-5, Hearings on H. R. 3300, Colorado River Basin Project, Part II U.S. Government Printing Office, Washington, D.C., 1968.

Estimates of Colorado River runoff based on hydrologic periods other than 1906-65 have been used in other investigations. Two such periods are the 1914-65 period with an average annual undepleted flow of 14.65 million acre-feet and the 1922-65 period with an average annual undepleted flow of 13.87 million acre-feet.

The annual virgin undepleted flow of the Colorado River at Compact Point, Lee Ferry, and the progressive 10-year average are shown on Figure C-1. It may be noted that the average virgin flow has been generally on the decline since 1929.

Local Runoff

About 100 million acre-feet of precipitation fall on the Region each year. Only about 3 percent of this reaches the streams or ground-water aquifers. The majority of the precipitation occurs in a relatively small percentage of the total regional area, primarily in mountains and high plateau areas. About one-half of the Region receives less than 10 inches of precipitation annually.

There is a wide variation in annual runoff within the Region. In the desert areas, where runoff is directly dependent on rainfall, the bulk of the flow, if any, occurs during the summer--July through September.

Above the major storage reservoirs, peak monthly runoff generally occurs during the March-June period as a result of snowmelt in the high mountains. Occasionally, floods of large magnitude occur in January and February during years of greater than average precipitation.

The distribution by subregion of average annual runoff (renewable water supply) is estimated as follows:

Table C-2
Estimated Annual Average Runoff 1/
Lower Colorado Region

Subregion	Millions of Acre-Feet
Lower Main Stem	0.90
Little Colorado	0.42
Gila	1.80
Total	3.12

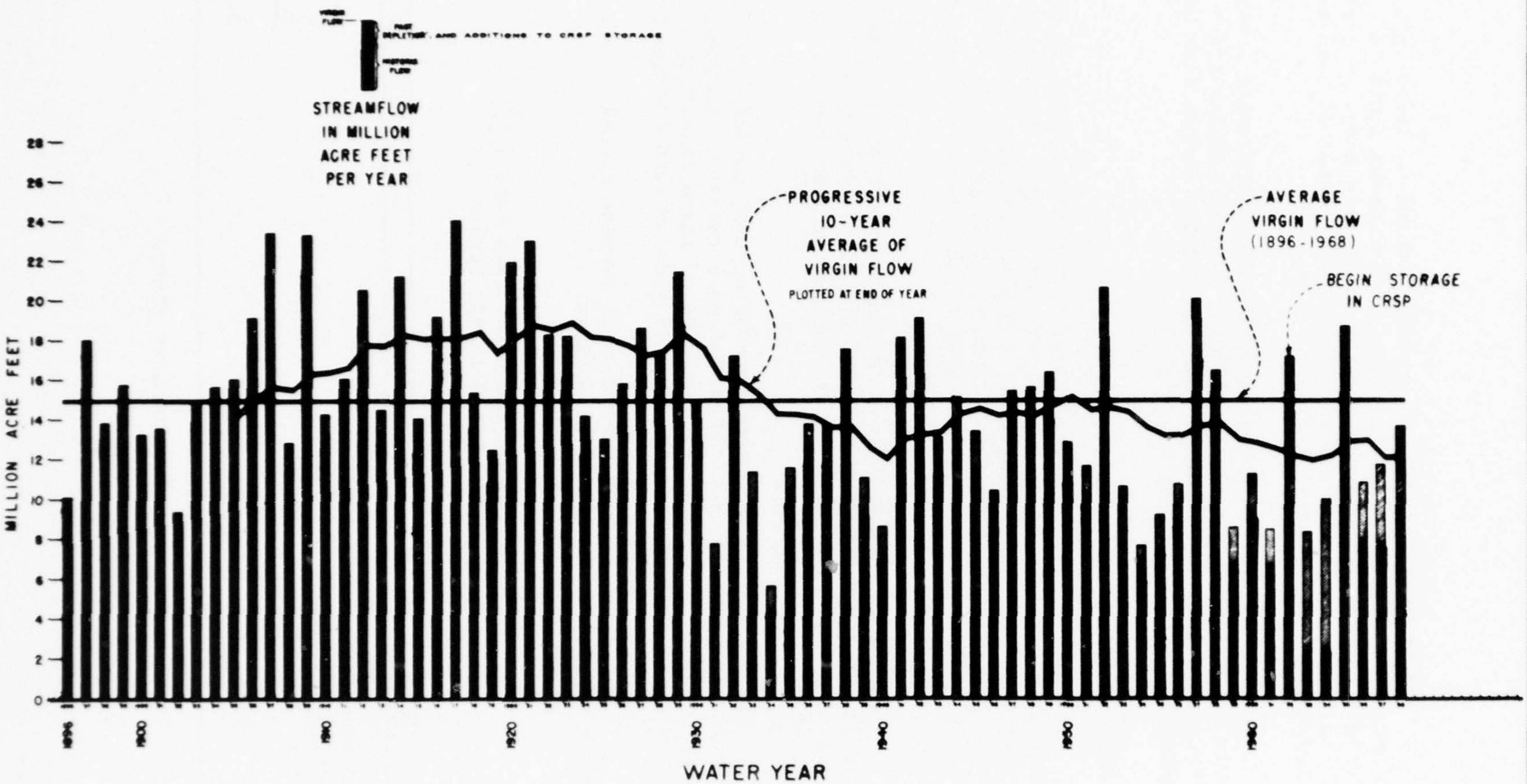
1/ Local, excludes Colorado River flows.

FIGURE C-1

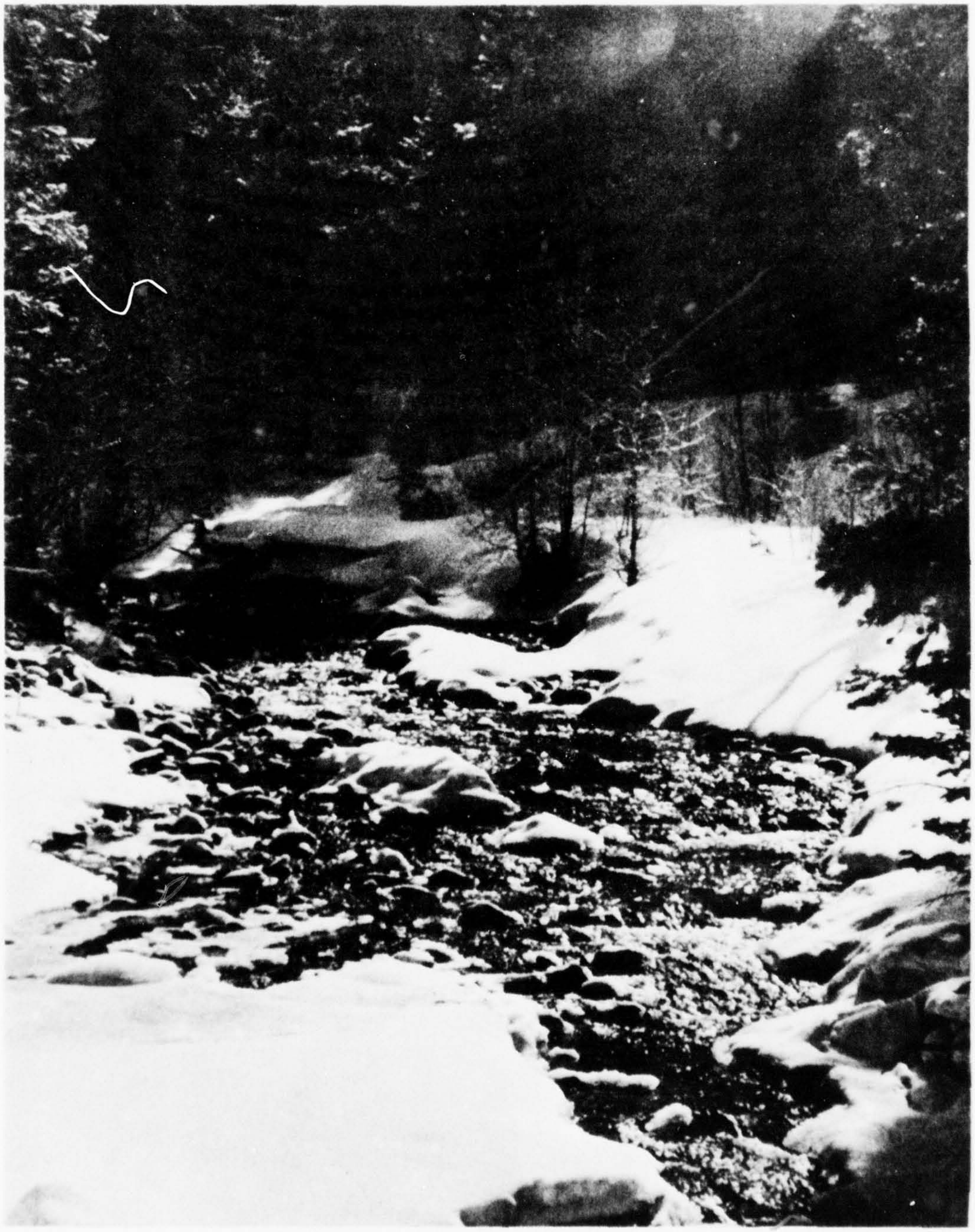
VIRGIN FLOW
COLORADO RIVER AT COMPACT POINT
LEE FERRY

AVERAGE VIRGIN FLOW

PERIOD	MAF
1896-1968	14.82
1906-1965	15.09
1914-1965	14.64
1922-1965	13.87
1931-1965	13.09



Alpine Snow Field, Mount Baldy, Arizona



Area of high water yield, mixed conifer, White Mountain area

The average renewable water supply contributed by the tributaries of the Lower Colorado River, exclusive of the Little Colorado and Gila Rivers, is estimated as about 0.9 million acre-feet annually. Tributary development is not extensive and most of this supply is consumed by uses along the main stem, including channel losses.

Under natural environment, the Little Colorado River contributed an average of about 0.42 million acre-feet annually to the Colorado River. A large portion of this supply is produced from saline springs near the mouth. Most of the water resource development in the Little Colorado Subregion is at and above Winslow, Arizona.

The average annual undepleted streamflow of the Gila River is estimated as about 1.8 million acre-feet in the upstream area of central Arizona, 1.3 million acre-feet at the site of Painted Rock Dam, and about 1.1 million acre-feet at the Colorado River. Channel losses through the desert reduced the flow considerably. Almost 90 percent of the estimated local water supply originates from the Salt River and the Gila River above Kelvin, Arizona.

Ground Water

Much of the present economic development of the Region has been made possible through the mining of the Region's ground-water reserves. Even though these reserves are still large, many problems attendant to their extraction and use may inhibit the further economical development of much of this resource in the Region.

As considered in this study, usable or recoverable ground water is that portion of total water in storage which could be extracted with equipment and methods now available, but without regard to economic, physical, legal, and environmental factors. Under this definition, the volume of recoverable ground water to a depth of 1,200 feet below land surface in the main aquifers in the Lower Colorado Region is estimated to be about 1,430 million acre-feet.

In the Lower Main Stem Subregion, about 620 million acre-feet of recoverable ground water are in storage to a depth of 1,200 feet below land surface. Of this, about 430 million acre-feet are in storage to a depth of 700 feet below land surface.

The tight nonalluvial formations found generally throughout the Little Colorado Subregion contain an estimated 250 million acre-feet of water in a 100-foot-thick section of the aquifer. Not all of the water contained in the tight formations of the Little Colorado Subregion is recoverable or usable because of low yields of wells in some areas and the high salinity of the ground water in parts of the aquifers in other areas.

AVAILABILITY

In the Gila Subregion about 800 million acre-feet of recoverable ground water are stored to a depth of 1,200 feet below land surface, some 560 million acre-feet of this above 700 feet in depth.

In most areas in the Lower Colorado Region where ground water is being pumped, it is being used far in excess of the rate of replenishment; consequently, water levels are declining, and pumping lifts and costs are increasing. Additionally, in some areas in central Arizona and Nevada where large amounts of water have been pumped, land subsidence has occurred. This subsidence has resulted in earth cracks, which disrupt natural drainage; sheared and collapsed well casings; misaligned highways, railroads, and irrigation canals; and has endangered structures, such as buildings and bridges. In areas where land subsidence has occurred, continuation of excessive pumping will cause additional damage. Continued dewatering of aquifers in areas not yet affected by land subsidence will certainly result in more cases of land subsidence. Another environmental effect of water table declines has been the dewatering of marshes and other wetland resources which are important as wildlife nesting and feeding grounds.

Some of the recoverable ground water is highly mineralized and would require treatment to make it suitable for either irrigation or domestic use. Some ground water contains objectionable concentrations of fluoride and boron which would preclude its use for many purposes.

The fact that large quantities of ground water exist and are not presently being utilized is evidence of the many problems and uncertainties that may be associated with developing this water for beneficial use. The practicability of development and utilization of much of these ground-water reserves involves many factors. Among the problems are poor quality water, deterioration of quality with depth or from recirculation by use, low yields from wells in some of the aquifers, remoteness of some aquifers from areas of present use, land subsidence associated with the dewatering of aquifers, the period during which a large overdraft can be maintained, and the legal rights of overlying land owners. Many of these problems have not yet been adequately evaluated and should be given priority in future studies.

Although there are areas where wells of high yields can still be drilled in some of the basins, much of these untapped reserves are at depths of more than 500 feet. Efficient mining of these waters, as well as much of the ground water located closer to the land surface, will require detailed well design, spacing, and installation of much deeper wells than currently exist in most areas. These ground-water reserves can continue to serve future generations if they are properly managed and integrated with other sources of water made available to the Region. In areas where long-range water resource planning concepts are not being followed, such concepts should be established that would conserve and regulate this nonrenewable resource as an optimum level, particularly in growing metropolitan areas where large water demands which will have to be sustained over long periods of time.

Depth to Water

A map following this page depicts depth to ground water, in feet below land surface, in wells tapping the main aquifers in the Lower Colorado Region for the base year 1965. For purposes of this presentation, depth to water is divided into four ranges--less than 200 feet, 200 to 500 feet, greater than 500 feet, and from 0 to 500 feet below land surface. Where data are lacking, mainly in remote or mountainous areas, no depth symbol is shown on the map.

The map presents a very generalized picture, and local exceptions occur. In some areas in Arizona, as parts of the San Simon Valley and the Safford Valley, the upper San Pedro River Basin near St. David, and part of the Navajo Indian Reservation, wells flow at land surface.

Change in Depth

A map following this page depicts changes in water levels in wells in the Lower Colorado Region from 1960 to 1965. The general picture is one of almost continuous water-level decline except in a few areas. Declines have been more than 60 feet in the 5-year period in the San Simon, Willcox, lower Santa Cruz, and Phoenix basins in Arizona and in the Las Vegas Basin in Nevada. Rises in water levels in wells have been associated with areas where drainage of applied surface water for irrigation is a problem, where pumping of ground water for irrigation has decreased, or where recharge to ground water has been above average.

Recharge to Ground Water

The ground-water reservoirs are recharged from several sources: (1) streamflow from precipitation in adjacent mountain ranges, (2) infiltration of excess applied irrigation water and canal seepage, (3) underflow from upstream basins, and possibly (4) direct penetration of precipitation.

Although a large part of the precipitation on the mountain ranges adjacent to the valleys is lost by evaporation or transpiration, a portion becomes runoff and reaches the coarse materials at the mountain fronts where it may recharge the ground-water reservoir. Data from the upper Santa Cruz River Basin indicate that from 3 to 6 percent of the precipitation on the mountains may become recharge to ground water. These percentages would not be exact for all the basins, but they probably are in the right order of magnitude.

A part of the water applied to the land for irrigation in the valleys is returned to the ground-water reservoir by infiltration. In some areas possibly as much as 25 percent of the water applied to irrigated fields may infiltrate to the ground-water reservoir but in other areas the amount is negligible. Some water also is returned to the ground-water reservoir by seepage from unlined canals.

In some basins, the ground-water reservoir is recharged by the movement of water by underflow from upstream ground-water basins through permeable materials separating the basins. While this movement of water by underflow is recharge to the downstream basin, it is discharge from the upstream basin and may not result in a net increase of available ground water to the Region or subregion.

Most of the precipitation that falls in the lower desert portion of the Region evaporates directly from the soil or is transpired by vegetation. Some water seeps downward to the ground-water reservoir where the precipitation falls directly on the coarse-grained materials along the washes that traverse the valley floor, but the amount probably is negligible.

Potential for Artificial Recharge

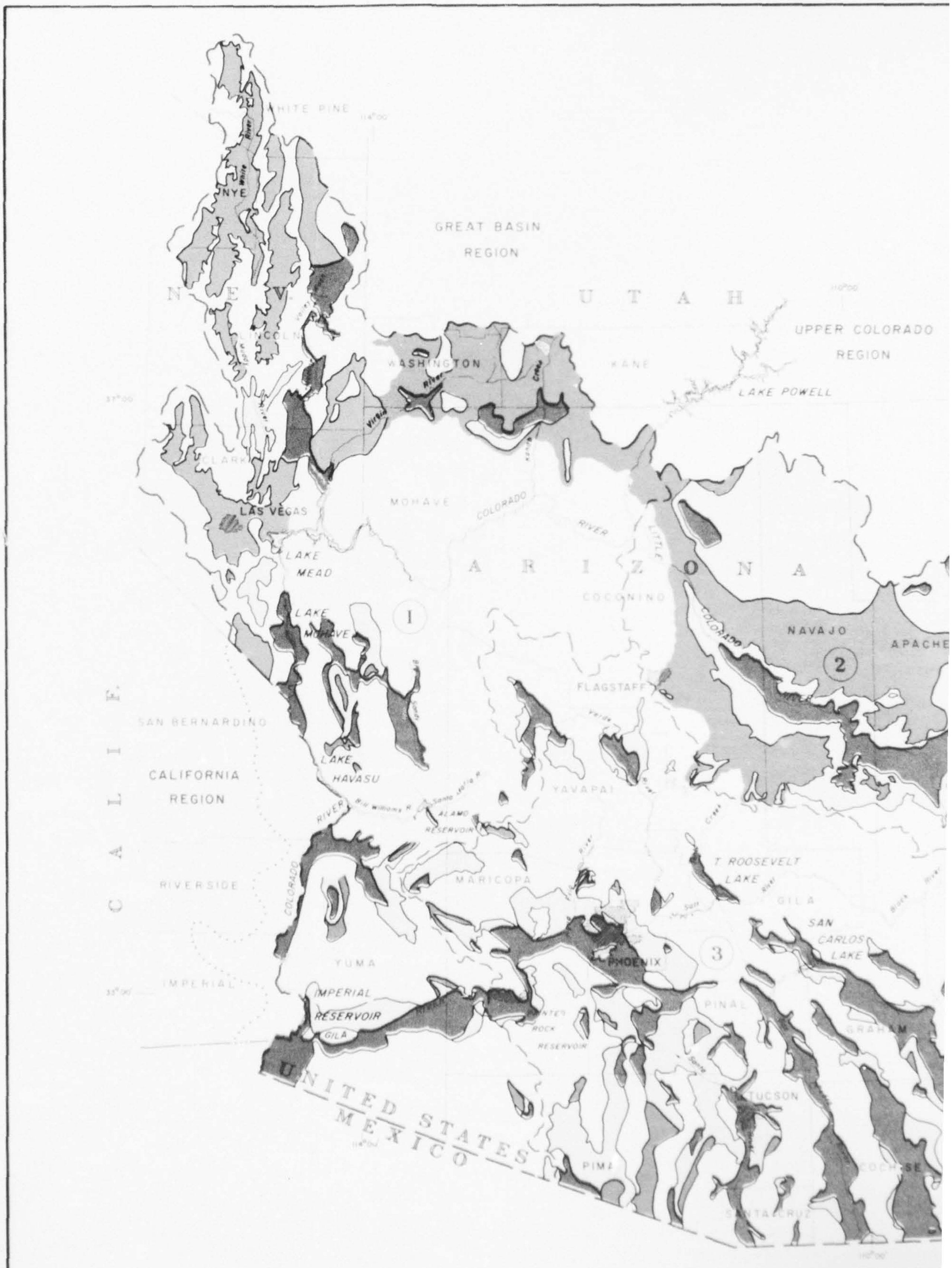
The potential for artificial recharge in the Lower Colorado Region is generally high. Dewatering of aquifers by pumping in excess of natural recharge has created potential reservoir space for ground-water storage and has increased ground-water gradients from recharge areas to centers of pumping. Existing stream channels are exceptionally efficient media for recharge. Data indicate that in the Santa Cruz River Basin as much as 86 percent of the total inflow to the river system may become recharge to the ground-water reservoir.

Present Water Supply Sufficiency

To illustrate sufficiency of regional water supply in 1965, an overall regional water balance was estimated by computing the remaining water supply in each subregion after all manmade depletions, evaporative losses, channel losses, system spills, and out-of-region diversions were subtracted.

Figure C-2, page 127, shows from a broad regional point of view that the total present water supply in the Region is nearly equal in amount to the total water requirements. The apparent water supply deficiencies in the Gila Subregion could be nearly offset assuming the hypothetical possibility of complete control and redistribution of water from areas of surplus.

Similar estimates, based on average annual depleted flows at the compact point for the 1914-1965 and the 1922-1965 periods of record, show 1965 regional water deficiencies of 0.63 million acre-feet and 1.40 million acre-feet, respectively.



WHITE PINE
NYE
GREAT BASIN
REGION
N E V
U T A H
UPPER COLORADO
REGION
LINCOLN
WASHINGTON
KANE
LAKE POWELL
CLARK
LAS VEGAS
MOHAVE
COLORADO
RIVER
LITTLE
LAKE
MEAD
A R I Z O N A
COCONINO
LAKE
MOHAVE
1
NAVAJO
APACHE
2
FLAGSTAFF
SAN BERNARDINO
CALIFORNIA
REGION
C A L I F.
LAKE
HAVASU
YAVAPAI
RIVER
ALAMO
RESERVOIR
T. ROOSEVELT
LAKE
RIVERSIDE
MARICOPA
GILA
SAN
CARLOS
LAKE
YUMA
PHOENIX
3
IMPERIAL
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PINAL
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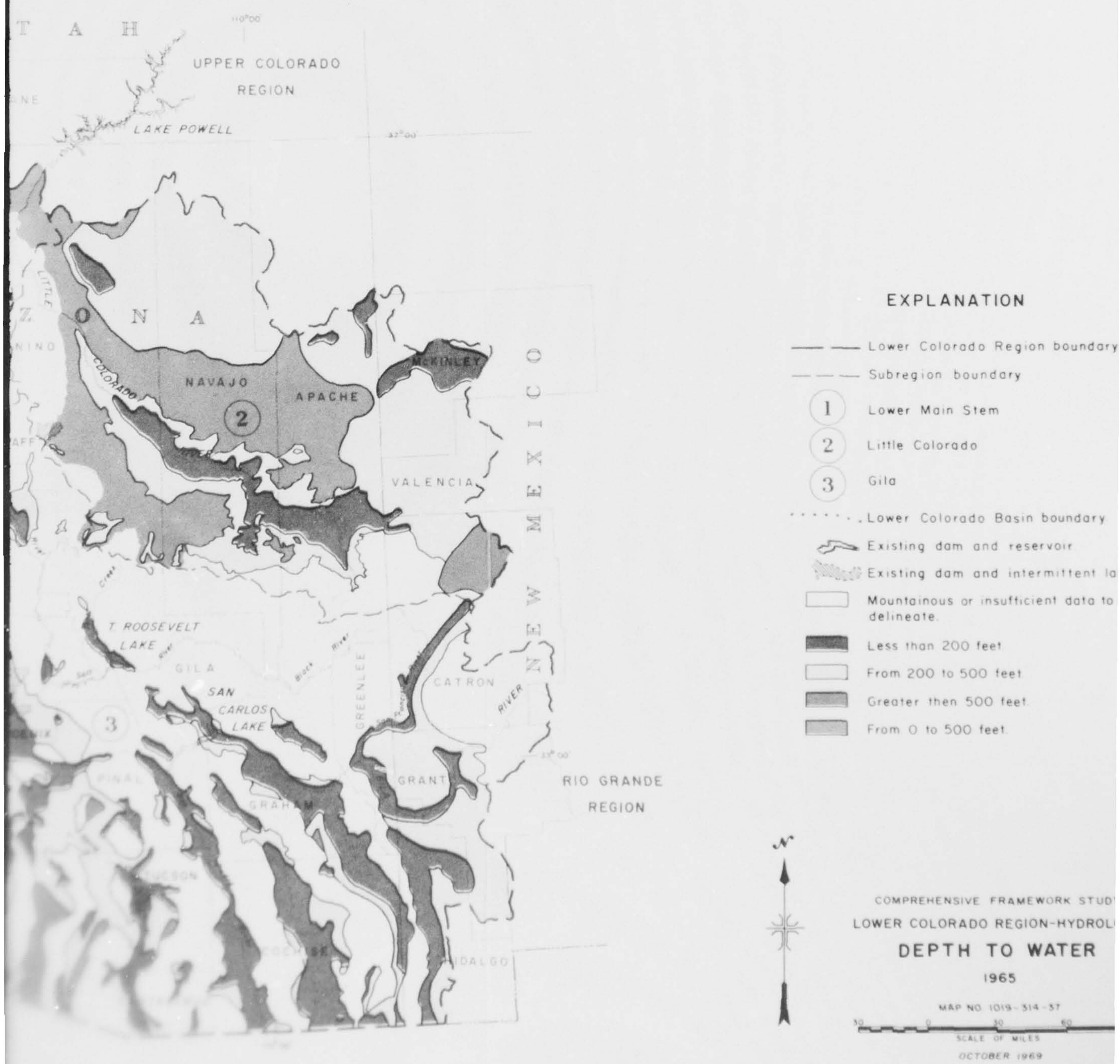
UNITED STATES
MEXICO
TUCSON
PIMA
SANTA CRUZ


UPPER COLORADO
REGION
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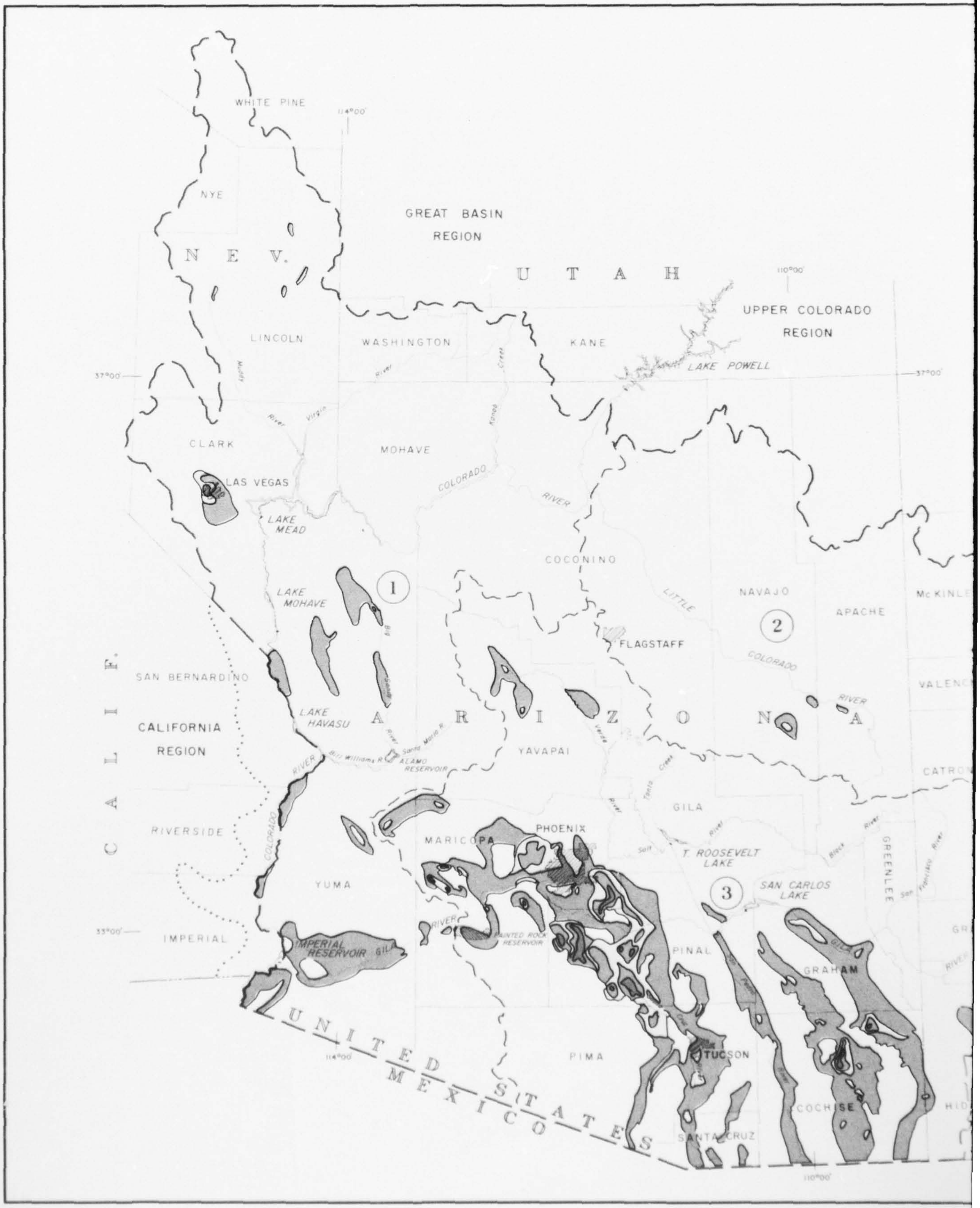
LAKE
GILA
SAN
CARLOS
LAKE
GREENLEE
CATRON
RIVER
GRANT
GRAHAM
RIO GRANDE
REGION
EXPLANATION
Lower Colorado Region boundary
Subregion boundary
1 Lower Main Stem
2 Little Colorado
3 Gila
Lower Colorado Basin boundary
Existing dam and reservoir
Existing dam and intermittent la
Mountainous or insufficient data to delineate.
Less than 200 feet
From 200 to 500 feet
Greater then 500 feet
From 0 to 500 feet
COMPREHENSIVE FRAMEWORK STUD
LOWER COLORADO REGION-HYDROL
DEPTH TO WATER
1965
MAP NO. 1019-314-37
SCALE OF MILES
OCTOBER 1969



WHITE PINE
NYE
N E V.
GREAT BASIN
REGION
U T A H
UPPER COLORADO
REGION
LINCOLN
WASHINGTON
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ALAMO
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RIVERSIDE
MARICOPA
PHOENIX
GILA
T. ROOSEVELT
LAKE
SAN CARLOS
LAKE
GREENLEE
YUMA
IMPERIAL
IMPERIAL
RESERVOIR
PAINTED ROCK
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PIMA
TUCSON
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UNITED STATES
MEXICO
114°00'
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37°00'
33°00'
1
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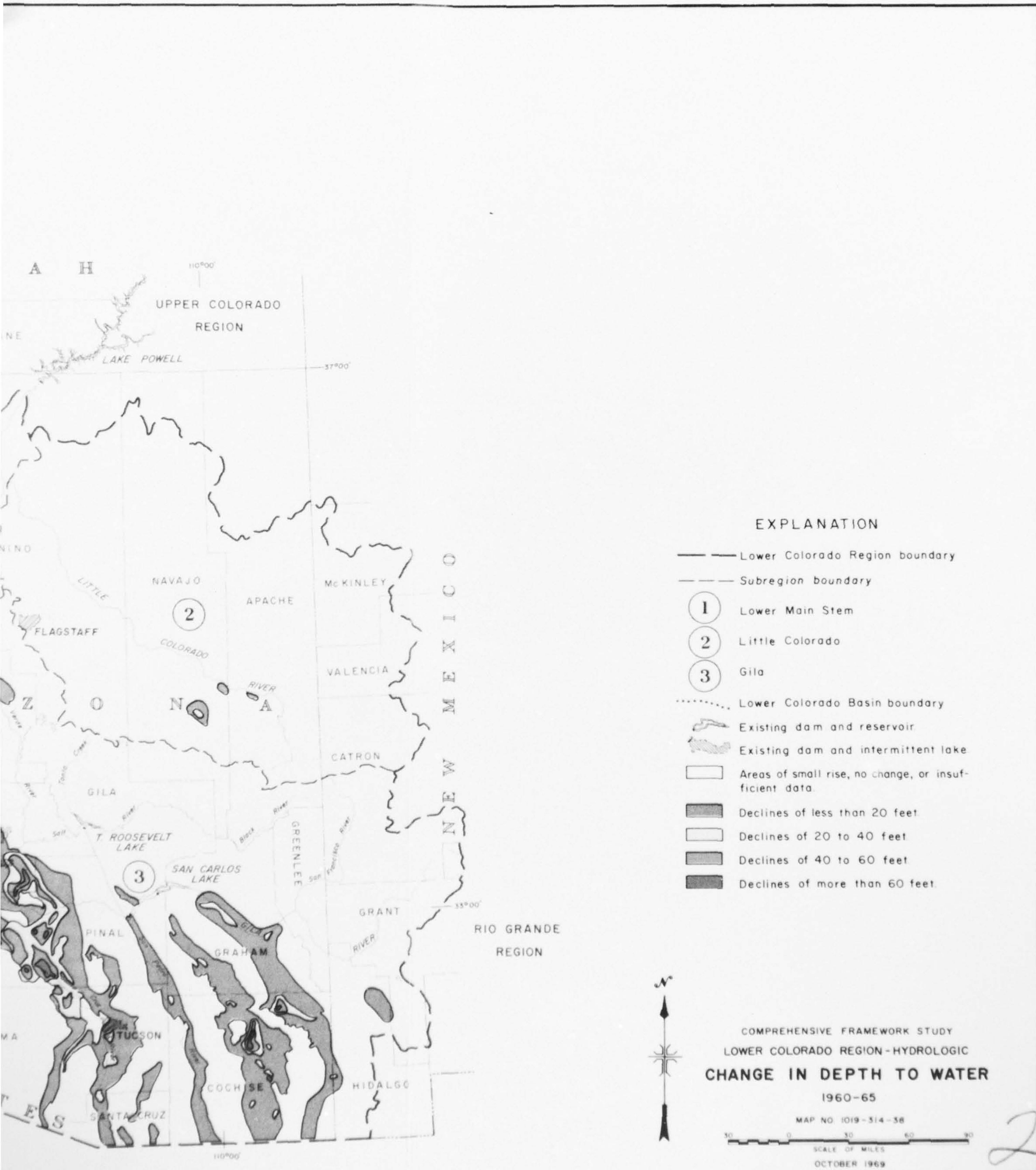

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110°00'
UPPER COLORADO
REGION
LAKE POWELL
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FLAGSTAFF
VALENCIA
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GILA
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3
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GREENLEE
GRANT
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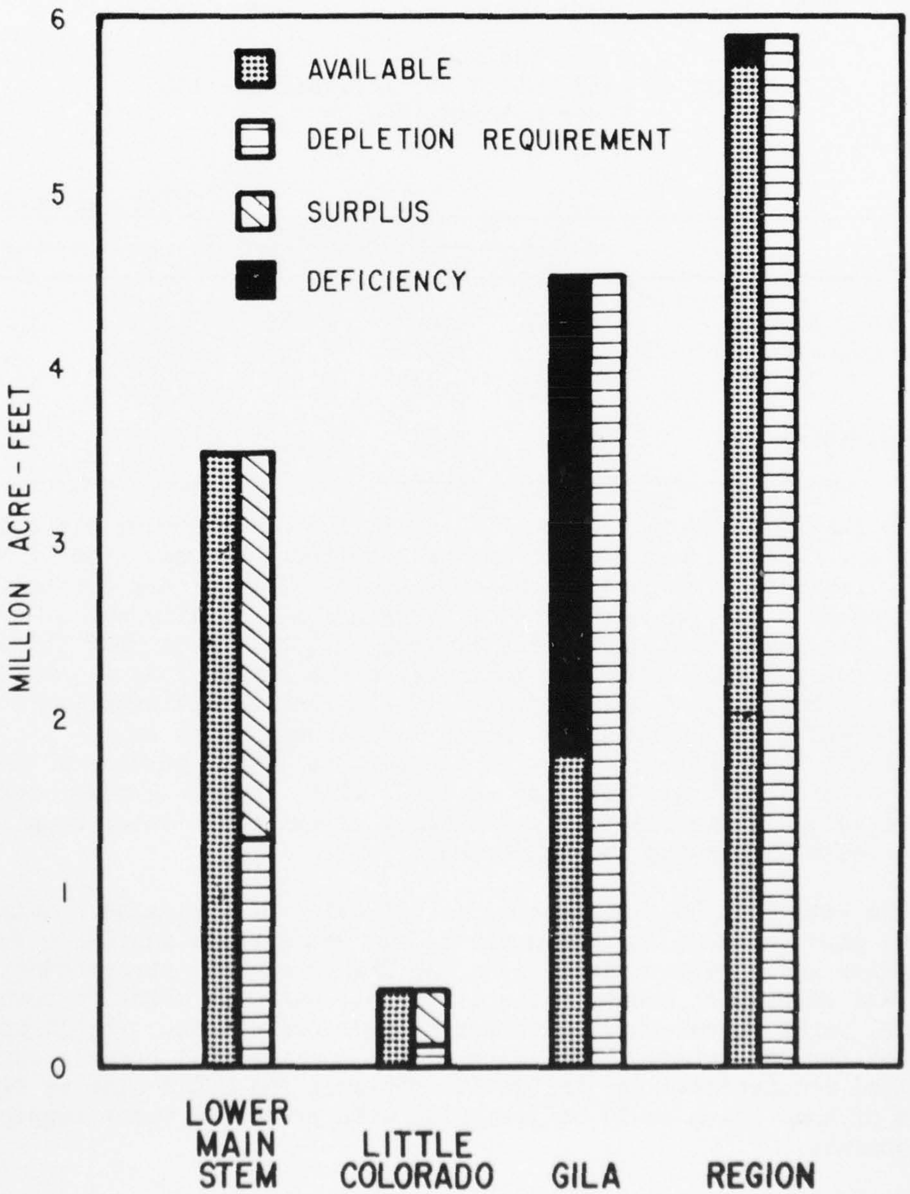
REGION
PINAL
GRAHAM
GILA
RIVER
TUCSON
COCHISE
HIDALGO
SANTA CRUZ
MA
T E S
110°00'
EXPLANATION
Lower Colorado Region boundary
Subregion boundary
1 Lower Main Stem
2 Little Colorado
3 Gila
Lower Colorado Basin boundary
Existing dam and reservoir
Existing dam and intermittent lake
Areas of small rise, no change, or insufficient data
Declines of less than 20 feet
Declines of 20 to 40 feet
Declines of 40 to 60 feet
Declines of more than 60 feet
N
COMPREHENSIVE FRAMEWORK STUDY
LOWER COLORADO REGION - HYDROLOGIC
CHANGE IN DEPTH TO WATER
1960-65
MAP NO. 1019-314-38
30 0 30 60 90
SCALE OF MILES
OCTOBER 1969
2

FIGURE C-2
REGIONAL WATER BALANCE
1965



AVAILABILITY

LANDS

Cultivated

In 1965, there were approximately 36.2 million acres of land suitable for irrigated cropland in the Region. Of this acreage, about 1.6 million acres were also suitable for nonirrigated crop production. Table C-3 presents acreage by land classes suitable for irrigation by subregion and region in 1965.

Table C-3
Acreage of Land Suited for Irrigation - 1965
Lower Colorado Region

Unit: 1,000 Acres

Subregion	Land Class 1	2	3	4	Total
Lower Main Stem	953	2,647	4,029	3,729	11,358
Little Colorado	575	1,052	2,765	2,409	6,801
Gila	4,040	4,118	4,538	5,360	18,056
Regional Total	5,568	7,817	11,332	11,498	36,215

As shown in the table, about 13.4 million acres are of Class 1 and 2 quality. Class 1 and 2 lands are well suited for production of all crops climatically adapted to the area where the lands are located. The remaining 22.8 million acres are of Class 3 and 4 quality which have restrictive characteristics reducing crop suitability or productive capacity of the land. The irrigation land classes include a consideration of onfarm land development criteria such as drainage improvement, leveling and clearing of trees, brush, or stones. They do not include consideration of factors affecting the feasibility of service such as location, size, and distribution of lands with respect to other lands to be developed, the quantity and quality of available water supplies, or the costs of pumping and conveyance.

The estimated 36.2 million acres suitable for irrigated cropland are the gross acreage for the Region. The net acreage available for irrigation would reflect deductions for rights-of-way; streambeds; urban and industrial areas; national forest; national wildlife refuges; national parks, monuments, and other high priority uses. Though not computed for this study, the resulting net acreage will greatly exceed projected requirements for irrigated croplands and would also be far in excess of that which could be irrigated with projected water supply developments.

Livestock Grazing

In 1965, there were approximately 85 million acres of land suitable for livestock grazing in the Region, of which about 76 million acres were available. This included 25 million acres of forest types (conifer, woodland, chaparral, and riparian), 51 million acres of range types (southern and northern desert shrub and grassland), all croplands, and portions of undeveloped lands within urban areas.

The difference between acreage suitable and that available was land allocated to uses whereby domestic livestock grazing is prohibited by existing laws, ownership, or restrictive uses. Examples are: national parks and monuments, research areas, portions of military reservations, and private lands managed for other uses.

Timber Production

The forest land considered in this analysis is that area capable of producing more than 20 cubic feet of industrial wood per acre per year under natural conditions. Of the 30 million acres of forest land in the Lower Colorado Region, 6 million acres are suitable for the production of commercial timber products. About one-half million acres of this land are included within the boundaries of national parks, monuments, wilderness, scenic and other areas having high recreation, watershed, scientific, and other uses where commercial timber harvesting is modified or precluded.

About 5.5 million acres within the Region are suitable and available for producing commercial timber products. Table C-4 shows the distribution of this acreage by ownership, administration, and subregion for 1965.

Table C-4
Lands Suitable and Available for Commercial Timber Production - 1965
Lower Colorado Region

Unit: 1,000 Acres

Subregion	Forest Service	Bureau Land Mgmt.	Indian Trust	State and County	Farmer	Misc. Private	Total
Lower Main Stem	844	6	--	3	10	10	873
Little Colorado	1,049	--	199	30	75	66	1,419
Gila	1,889	7	1,070	12	174	14	3,166
Total Region	3,782	13	1,269	45	259	90	5,458

AVAILABILITY

Urban and Industrial

The availability of land for urban and industrial uses is related to the location of population growth and development. Physical land characteristics are not as limiting as for other uses. However, restrictive land uses (such as military), susceptibility to floods, extremely rugged topography, lack of public facilities, etc., often present serious obstacles to development for these purposes.

Land in national parks, national forests, and wildlife refuges are available to a very limited degree for urban and industrial development (mostly resorts).

Outdoor Recreation

The lands available for outdoor recreation within the Region total over 68 million acres and include private as well as public lands. Table B-21 indicates the distribution of land by recreation class controlled by public agencies which is available for outdoor recreation use. A substantial amount of private land holdings have been inventoried by recreation land class and is available for at least some limited recreation use. Multiple-use public and private lands, wilderness lands, fish and wildlife lands, and lands listed in urban requirements also will be required to meet recreation needs. Indian Trust lands, considered as private, have very good potential for outdoor recreation development within the Region.

Minerals

Availability of land for mineral production is chiefly a function of availability of the resource and of changing demand and technology. Large amounts of land are not required for mineral production and such lands will be available when demand for the resource makes new developments economically feasible.

Fish and Wildlife

Practically all land and water areas within the Region are suitable for some use by fish and wildlife. Urban, transportation and recreation lands and waters, where heavy public use occurs, offer limited wildlife habitat.

The total area of streams and impoundments having suitable fish habitat (0.25 million acres) in 1965 was available for fishing and associated uses. The total area suitable and available for hunting big game, small game, and waterfowl within the Region in 1965 was 76.4 million acres. An estimated 13.9 million acres of wildlife habitat were unavailable for hunting purposes because of ownership, existing laws, or restrictive uses. Table C-5 shows habitat types and acreages suitable and available for fishing and hunting in the Region in 1965.

Table C-5
Important Fish and Wildlife Habitat - 1965
Lower Colorado Region

Vegetal Cover	Total Lands Each Type Acres (1,000's)	Percent	Available for Fishing and Hunting Acres (1,000's)	Percent of Regional Total
Conifer Forest	6,522.0	7.2	6,500.0	7.2
Woodland	19,903.0	22.0	19,500.0	21.6
Chaparral	3,466.0	3.8	3,400.0	3.7
Southern Desert Shrub	32,137.0	35.6	22,000.0	24.3
Northern Desert Shrub	8,547.0	9.5	7,600.0	8.4
Grassland	16,902.0	18.7	16,000.0	17.7
Riparian	106.0	0.1	97.0	0.1
Urban, Transportation	513.0	0.6	0.0	0.0
Cropland	1,816.0	2.0	1,000.0	1.1
Water	340.0	0.4	260.0	0.3
Barren	76.0	1.0	68.0	0.1
Regional Total	90,328.0	100.0	76,425.0	84.5

See Vegetal Cover Map following page XVIII-42.

Military and Related Uses

The land presently in military and related uses in the Region is barren desert or semiarid mountainous terrain. This land was selected for military uses because it was isolated from developed areas and because there was a low demand for most other uses. There are additional areas in the Region that meet these requirements and that could be made available if and when the need arises. The land most readily available for this use would be land still in public domain.

Preservation of Natural, Historic, and Cultural Values

Cultural Values

Through appropriate action by state and Federal legislative bodies, adequate lands could be made available for the recommended sites for preservation of cultural and historic values.

Wild and Scenic Rivers

Consideration of 12 stretches of river has been recommended in the Recreation Appendix for study as potential wild, scenic, and recreation

rivers. Generally, there is an ample amount of suitable reparian land available for preservation of wild and scenic rivers, though conflicts may develop as more specific river reaches are identified. See map following for potential wild, scenic, and recreation rivers.

Wilderness Areas

In addition to the nearly 1.5 million acres of existing designated wilderness areas, there are some 1.7 million acres that have been suggested for potential wilderness areas. It is anticipated there will be substantial blocks of suitable land available for designation as wilderness areas.

Archeological Sites

The Region's unstudied archeological resource is highly significant to the understanding of the prehistory of the Southwest. It consists of thousands of sites ranging from ancient stone chipping stations of the Lithic Stage through the spectacular architectural remains of the 10th-13th century Anasazi, Mogollon, and Hohokam villages, to the evidences of the historic American Indian period such as Awatovi Ruins or the Seven Cities of Cibola. The sites represent the sum of man's activities in the Region from most ancient times to most recent history.

MINERALS

Minerals customarily produced in the Lower Colorado Region in important quantities are assumed to exist in known and unknown mineral deposits in sufficient quantities to satisfy all reasonable demands, when such demands are supported by realistic prices and mineral development is not unduly hindered by regulatory or environmental constraints. Those minerals produced for consumption almost exclusively within the Region--sand, gravel, stone, lime, and other construction materials--seemingly are present in inexhaustible quantities. Quantities of existing deposits of lead, zinc, and uranium cannot be fully defined; there is, however, a vast area in which geologic conditions appear favorable for future discoveries when economic incentives warrant the exploration effort. Copper, backbone of the regional minerals industry, has an exceptionally strong resource base.

Access for exploration and development of both public and private mineral-bearing land has been assumed to be readily available when subsequent mining operations are developed in an orderly manner with due consideration to environmental factors.

GEOTHERMAL RESOURCES

Although the Lower Colorado Region has several dozen springs classified as "thermal," none have exceptionally high temperatures. Very deep alluvial basins with high contents of thermal water sufficient to be of economic interest may possibly occur in the Region; however, if such do occur, they have not obvious surface expression and have remained undiscovered by drilling. In general, the geothermal potential of the Region is presently unknown. Areas south and west of the Colorado Plateau are likely to have conductive heat flows 25-50 percent higher than the worldwide "normal" and may have some geothermal potential.

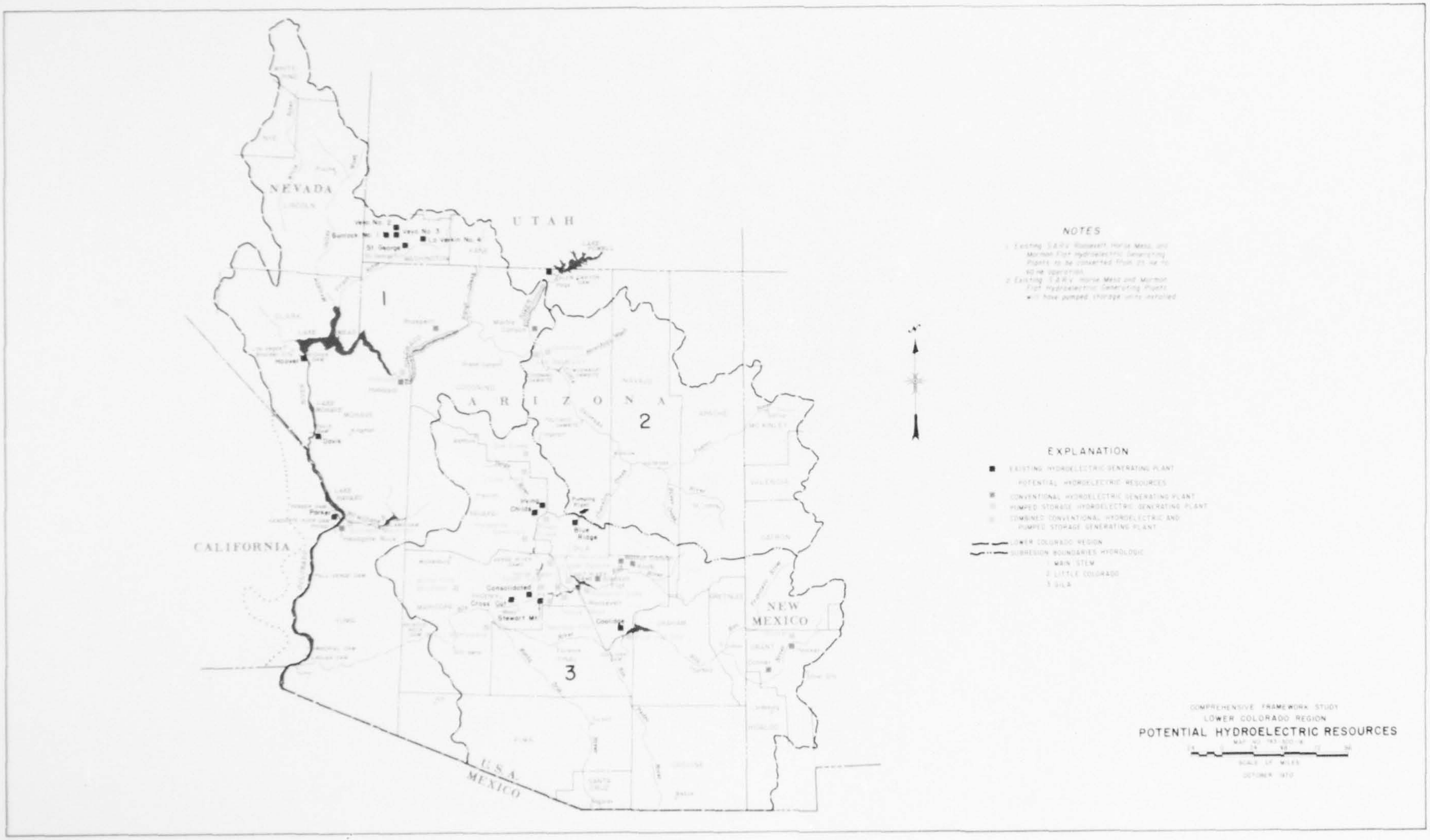
HYDROELECTRIC POWER SITES

There are a significant number of potential conventional and pumped storage hydroelectric power generation sites remaining in the Region. Although many of these sites have been only briefly studied and the conservationists oppose the development of some sites, especially on the Colorado River between Lake Mead and Lake Powell, these remain a potentially available resource of the Region. See map following for locations of potential hydroelectric resources.

WILD, SCENIC, AND RECREATION RIVER POTENTIAL

COMPREHENSIVE FRAMEWORK STUDY
LOWER COLORADO REGION

I	Colorado River - Glen Canyon Dam to Lake Mead
II	North Fork Diamond Creek
III	Little Colorado River - Grand Falls to confluence with Colorado River
IV	Oak Creek - source to confluence with Verde River
V	Chevelon Creek
VI	Verde River - headwaters of Horseshoe Lake to confluence with West Clear Creek
VII	East Verde River
VIII	Tonto Creek
IX	White River
X	Salt River - source to Stewart Mountain Dam
XI	Black River
XII	Gila River - source to Florence
XIII	Colorado River - Davis Dam to International Boundary (particularly Topock Gorge and Imperial Division)


NEVADA
UTAH
ARIZONA
CALIFORNIA
NEW MEXICO
U.S.A.
MEXICO
1
2
3
Hoover
Davis
Parker
St. George
Consolidated
Stewart Mt.
Coolidge
Blue Ridge
NOTES
1. Existing S.R.P.V. Roosevelt, Horse Mesa, and Mormon Flat Hydroelectric Generating Plants to be converted from 25 hz to 60 hz operation.
2. Existing S.R.P.V. Horse Mesa and Mormon Flat Hydroelectric Generating Plants will have pumped storage units installed.
EXPLANATION
EXISTING HYDROELECTRIC GENERATING PLANT
POTENTIAL HYDROELECTRIC RESOURCES
CONVENTIONAL HYDROELECTRIC GENERATING PLANT
PUMPED STORAGE HYDROELECTRIC GENERATING PLANT
COMBINED CONVENTIONAL HYDROELECTRIC AND PUMPED STORAGE GENERATING PLANT
LOWER COLORADO REGION
SUBREGION BOUNDARIES HYDROLOGIC
1 MAIN STEM
2 LITTLE COLORADO
3 GILA
COMPREHENSIVE FRAMEWORK STUDY
LOWER COLORADO REGION
POTENTIAL HYDROELECTRIC RESOURCES
SCALE OF MILES
OCTOBER 1970

FUTURE REQUIREMENTS

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LOWER COLORADO REGION COMPREHENSIVE FRAMEWORK STUDY. APPENDIX X--ETC(U)
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CHAPTER D - FUTURE REQUIREMENTS

INTRODUCTION

The Lower Colorado Region's projected growth in population economy is dependent on solving the present problems of water d ciency and providing for future needs.

Each functional appendix has evaluated the future need for and land to provide for the projected growth of the Region. Un original framework planning policies, future water needs to mee projections were to be unconstrained because water is a transfe resource. However, in recognition of the probable high cost of ing water into the Region, projected irrigated acreage was, in constrained by water supply; therefore, projections do not incl consideration of maximum agricultural potential and related eco activity.

The requirements of a growing population necessitate plann development and management of all aspects of water and related resources. The demand for municipal and industrial water is ex to increase by 370 percent by year 2020. Electric power must b vided for homes and industry and this demand is expected to inc fortyfold and will result in increased water withdrawal require power production. The increasing leisure time of a growing pop will create greater demand for outdoor recreational development additional land is developed to meet the many needs of the popu increased flood protection will be required; water quality and lution become ever increasing problems where nearly all water i utilized.

The land resources must be managed for increased intensity multipurpose uses to provide for such needs as livestock grazin life, recreation, timber production, environmental consideratio to reduce flood damages in both urban and rural areas. The sec following in this chapter present a consolidation of the patter development and projected requirements for water and related re developed in the other appendixes.

ECONOMIC PROJECTIONS

The projections presented in the following sections are based on historical trends and the magnitude and direction of current economic activity in the Region. The selected measures of economic growth include population, employment, personal income, sales to final demand, and total sales.

Population

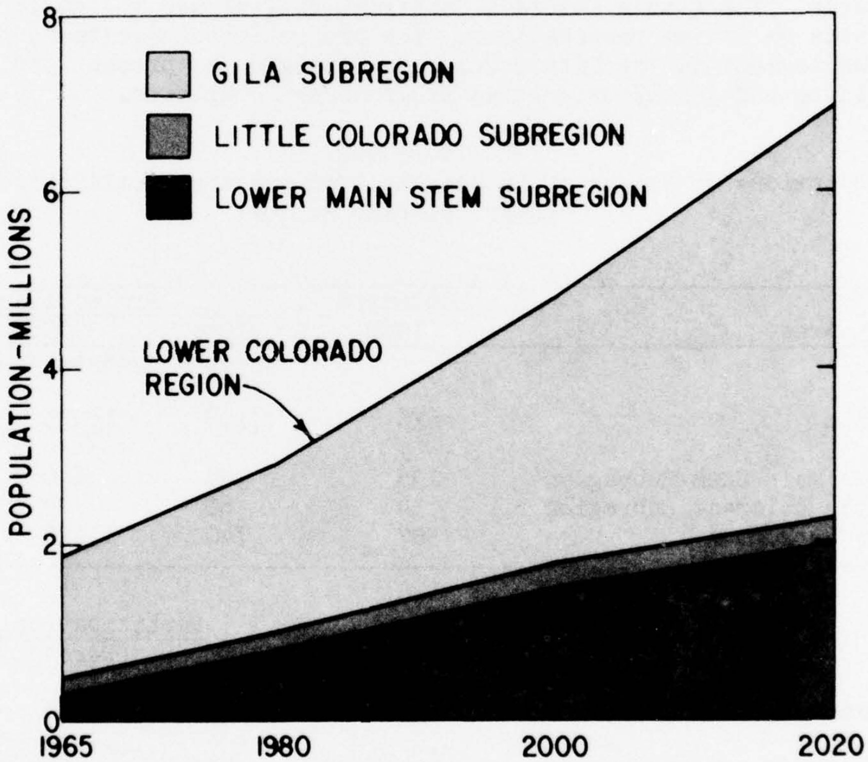
Population in 1965 and projections to the year 2020 for the Lower Colorado Region by subregion are shown in Table D-1. Total population is expected to increase from about 1.9 million in 1965 to nearly 7.0 million by 2020. The Gila Subregion is expected to continue to dominate as far as total numbers are concerned. See Figure D-1.

Table D-1
Estimated and Projected Population
Lower Colorado Region

Area	Estimated 1965	Projections 1980	2000	2020
		---------Thousands-----------		
Region (Economic)	1,877	2,911	4,797	6,983
Lower Main Stem Subregion	345	816	1,520	2,021
Little Colorado Subregion	125	184	240	326
Gila Subregion	1,407	1,911	3,037	4,636
Region (Hydrologic)	1,847	2,867	4,722	6,877
Lower Main Stem Subregion	313	762	1,429	1,875
Little Colorado Subregion	151	224	293	389
Gila Subregion	1,383	1,881	3,000	4,613

Within the Economic Region, however, the most rapid population growth rate is projected for the Lower Main Stem Subregion with the 2020 population of 2.0 million being about 6 times the 1965 population. A major part of this increase is projected to take place in the Nevada portion of the Subregion where an eightfold increase in population is projected by 2020. The Gila Subregion ranks second in rate of population growth, although the relative increase by 2020 is only a little over one-half that of the Lower Main Stem Subregion. However, with its large 1965 population base, the increase in number of people in the Gila Subregion (3.2 million) is double the increase (1.6 million) in the Lower Main

FIGURE D-1
POPULATION GROWTH
ECONOMIC REGION



Stem Subregion. Population of the Little Colorado Subregion is projected to increase more than $2\frac{1}{2}$ times over the 55-year period, reaching 326,000 by 2020.

Employment

Employment in the Lower Colorado Region is projected to increase from 676,000 in 1965 to about 2.8 million in 2020, an increase of 320 percent (see Table D-2). The employment participation rate of the Lower Main Stem and the Gila Subregions compares favorably with national figures. The Little Colorado Subregion differs due to the large poverty packets on Indian reservations. The projections indicate an improvement in employment in the Little Colorado Subregion as present and anticipated training and job opportunities programs are completed.

Table D-2
Projections of Number of People Employed and the Participation Rate
Lower Colorado Region

Area	Estimated 1965	Projections 1980	2000	2020
		----Employment--Thousands----		
Region	676	1,138	1,935	2,833
Lower Main Stem Subregion	135	338	640	859
Little Colorado Subregion	34	60	85	120
Gila Subregion	507	740	1,210	1,854
		Participation Rate (Percent)		
Region	36	39	40	41
Lower Main Stem Subregion	39	41	42	42
Little Colorado Subregion	27	33	36	37
Gila Subregion	36	39	40	40

Economic Activity

Industrial output levels by major groups, value added, and imports for each subregion are shown in Table D-3 for 1965 with modified OBE-ERS projections to 1980, 2000, and 2020. In most instances the primary industries are expected to more than double their output levels over the projection period. At the same time, however, an increase equal to 23 times is expected in manufacturing output levels in the Lower Main Stem Subregion with increases of 16 and 9 times in the Gila and Little Colorado Subregions, respectively.

Tertiary, or noncommodity producing industries, in the Lower Main Stem Subregion are expected to account for 85 percent of total industrail output by the year 2020, as compared to about 75 percent in the base year. Much of the expected growth and development relates to increased demand for goods and services by local markets, but more important is the goods and services produced for outside markets. Exports of electric power, for example, and sales outside the Region by such business sectors as transportation and finance, are important sources of basic income. A major demand for goods and services from outside the Region, however, stems from outdoor recreation and tourism.

Out-of-region direct recreation expenditures in the Region have been estimated to be $252 million for 1965 and are projected to reach $428 million by 1980, $738 million by 2000, and $1,154 million by 2020. The magnitude of these values reveals the importance of outdoor recreation and tourism as a source of "new dollars" to the regional economy.

Value added, made up largely of government payments and income payments, amounted to $.22 billion in 1965 and is projected to reach about $4.8 billion by 2020 in the Little Colorado Subregion. Similar projections for the Lower Main Stem Subregion show value added increasing from $1.3 billion in 1965 to approximately $35.2 billion in 2020. In the Gila Subregion, which accounted for 75 percent of total value added in the Lower Colorado Region in 1965, projections indicate an increase from $4.5 billion in 1965 to $73.5 billion in 2020.

Gross regional product (GRP) measures the flow of product as opposed to the flow of income and payments (value added) discussed above. Projected levels of GRP are given in Table D-4. The reader will note that total GRP in each subregion is equal to total value added in each subregion which has been shown above and need not be repeated. Thus, the regional accounts in terms of broad categories have been measured using regional income figures (value added) and by using regional product figures (gross regional product).

Agriculture

The irrigated acreage of crops harvested in the Region is projected to increase from 1.2 million in 1965 to nearly 1.6 million in 2020, an increase of 358,000 acres during the 50-year period. A major part of this increase--224,000 acres--is projected for the 1965-1980 period. Another 95,000-acre increase is projected for the 1980-2000 period, with the remaining 39,000-acre increase to occur in the 2000-2020 period.

Food crops are projected to increase substantially. The vegetable acreage is projected to increase 2.5 times by 2020. A similar increase is projected for the citrus acreage. The no citrus fruit and nut acreage is projected to increase 4.5 times by 2020.

REQUIREMENTS

By the year 2020, acreage of cotton in the Region is projected to increase 20 percent; acreage of feed grains and hay is projected to decline; and the number of livestock is projected to increase as follows:

The number of range cattle is projected to increase by about 20 percent; a fourfold increase is projected for cattle fattened in feedlots; the number of milk cows is projected to double; numbers of sheep and lambs are projected to decline; the number of hogs marketed is projected to increase about 20 percent; the number of laying hens is projected to increase modestly with a greater increase projected in numbers of broilers and turkeys marketed; and, the number of horses is projected to increase substantially.

Forestry

The annual timber harvest in the Region is projected to reach 130 million cubic feet by 2020, a 58 percent increase over the 1965 harvest. Saw logs are projected to account for 51 percent of the total harvest with veneer logs, pulpwood, and other making up 22, 21, and 6 percent, respectively. Although the timber industry is only a small portion of the total regional economic activity, rather large pulp, paper, lumber, and wood product industries stem from its output. Forestry, therefore, is of major importance, especially to many rural areas in the Region.

Mineral Industry

The projected mineral industry accounts for less than one percent of total regional employment in each projected period. Copper industry is projected to continue to be the largest mineral industry. However, uranium is projected to make the greatest expansion, especially in the Little Colorado Subregion. Mining of sand and gravel and other minerals is projected to expand substantially in order to supply the inputs for construction, chemicals, and other manufacturing industries.

Manufacturing

Projected growth rates for the food and food processing sectors (secondary agricultural activity) compare well with growth rates in other manufacturing and commercial activities. Food processing particularly of fruits and vegetables, is expected to continue as an important part of total manufacturing activity. Such manufacturing groups as metal fabrication, printing and publishing, electrical equipment, machinery, and chemicals are presently of major economic importance and are expected to continue. The primary metals sector accounts for about 24 percent of present total manufacturing output, but declines in relative importance throughout the period. Other industries, such as electronics and research and development related activities, on the other hand, are expected to increase in importance in the future.

Table D-3
Total Gross Output by Industry and Associated Total Primary Inputs
Economic Subregions

Subregion and Item	Estimated 1965	Modified OBE-ERS Projections 1980	2000	2020
	-----------Million 1960 Dollars-----------			
Lower Main Stem				
Producing Industries				
Agriculture	123.3	196.9	269.9	365.8
Forestry	5.2	7.7	9.4	9.5
Mining	32.1	126.3	153.2	189.0
Manufacturing	197.1	766.3	2,168.4	4,557.4
Noncommodity Producing Industries	1,220.5	4,586.6	13,634.3	28,931.7
Total	1,578.2	5,683.8	16,235.2	34,053.4
Value Added	1,280.2	5,298.5	16,464.6	35,233.8
Imports	776.4	2,673.6	7,791.6	17,071.6
Little Colorado				
Producing Industries				
Agriculture	14.7	17.6	23.6	30.1
Forestry	7.3	7.4	7.4	6.8
Mining	112.2	967.5	897.7	852.8
Manufacturing	72.0	183.1	325.2	629.4
Noncommodity Producing Industries	138.4	284.5	654.1	1,375.1
Total	344.7	1,460.1	1,908.0	2,894.2
Value Added	224.1	867.7	2,042.2	4,834.9
Imports	205.5	855.0	1,129.7	1,663.8
Gila				
Producing Industries				
Agriculture	458.4	726.0	991.5	1,289.9
Forestry	2.1	4.3	6.0	6.4
Mining	458.5	652.0	953.0	1,268.0
Manufacturing	1,759.1	4,335.2	11,486.7	27,908.2
Noncommodity Producing Industries	2,977.7	6,442.5	16,773.8	39,501.8
Total	5,655.8	12,160.0	30,211.0	69,974.3
Value Added	4,524.4	10,342.9	28,706.2	73,491.8
Imports	2,257.8	4,364.0	11,027.9	27,055.8

Noncommodity

Projected growth rates in construction, transportation, and utilities related closely to meeting the needs of the projected population and industrial growth. Employment in these sectors to 2020 will vary from an annual increase of about 2.1 percent in construction to 1.8 percent for utilities.

The trade, service, finance, and real estate sectors are expected to gain in their share of total economic activity during the period.

Government's share of total employment, especially state and local, is expected to increase throughout the projection period.

Table D-4
Gross Regional Product, 1965 and
Modified OBE-ERS Projections
Lower Colorado Region

Unit: $1,000,000

Subregion	1965	1980	2000	2020
Lower Main Stem	1,280.2	5,298.5	16,464.6	35,233.8
Little Colorado	224.1	867.7	2,042.2	4,834.9
Gila	4,524.4	10,342.9	28,706.2	73,491.8
Gross Regional Product	6,028.7	16,509.1	47,213.0	113,560.5

WATER REQUIREMENTS

Lower Colorado Region

From the broad point of view, present regional water supplies were sufficient to meet all requirements if facilities had been available to convey water from areas of excess to the water deficient Gila Subregion. By 1980, assuming adequate diversion and conveyance of available supplies, projections indicate a water deficiency of about 1.5 million acre-feet, increasing to more than 4.5 million acre-feet by 2020. Previous studies have indicated that the Colorado River flows would need to be augmented to fulfill present commitments of 3.1 maf to the Lower Colorado Region, 4.4 maf to California, and 1.5 maf to the Republic of Mexico.

Estimated present projected regional water withdrawal and depletion requirements are presented in Table D-5. It should be noted that this is a table of estimated water requirements; quantity actually withdrawn in 1965 is shown in footnote to the table. Water requirements for all uses are expected to increase to a level of 13.0 million acre-feet by 2020. Projected increases are associated primarily with the needs resulting from population growth in the Region. Municipal and industrial water withdrawal requirements are expected to increase 2.3 maf; for electric power generation, 0.4 maf; for mineral development, 0.2 maf; and for recreation, fish, and wildlife, 0.4 maf. Irrigation withdrawal requirements would remain about the same level as for 1965. Water saved by increasing management efficiencies and lining of canals would just about meet increased requirements resulting from projected additional developments. Figures D-2 and D-3 also show projected requirements.

Ground-water withdrawals, estimated presently to exceed recharge by about 2.5 million acre-feet annually, must be reduced substantially during the study period. There are impelling reasons to replace the practice of excessive ground-water overdrafts with other sources of water. Such reasons include: increased cost of pumping; degrading water quality; land subsidence; and the ultimate potential of totally exhausting the resource in areas of intensive use.

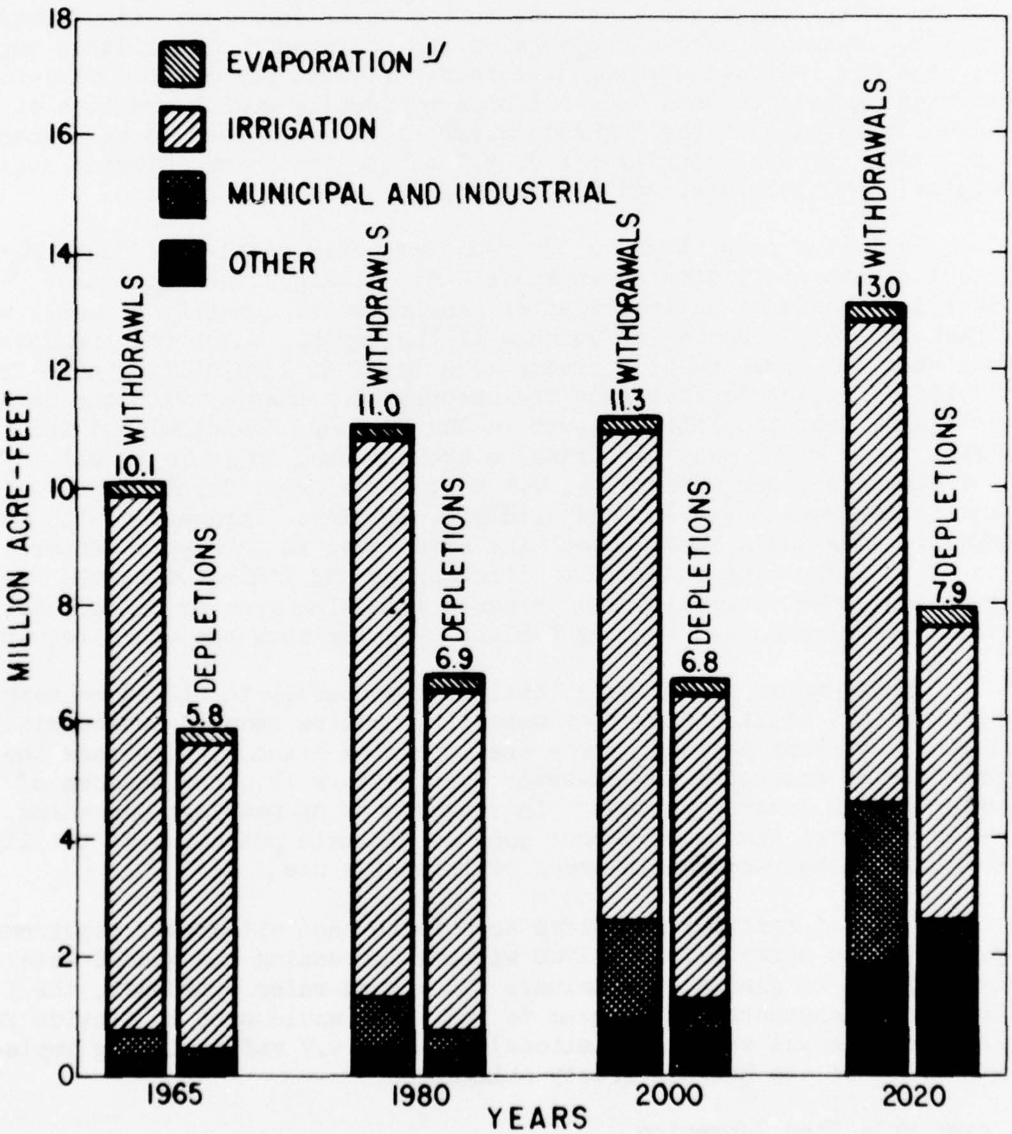
The most critical immediate need is to meet withdrawal requirements projected to occur prior to 1980 without increasing the ground-water overdraft. To gradually eliminate the ground-water overdraft, the long-range augmentation program to year 2020 would need to provide for increased annual water (depletions) of about 4.7 maf including implementation of the Mexican Treaty obligation.

Lower Main Stem Subregion

The present and projected water withdrawal and depletion requirements for the Lower Main Stem Subregion are summarized in Table D-6.

FIGURE D-2

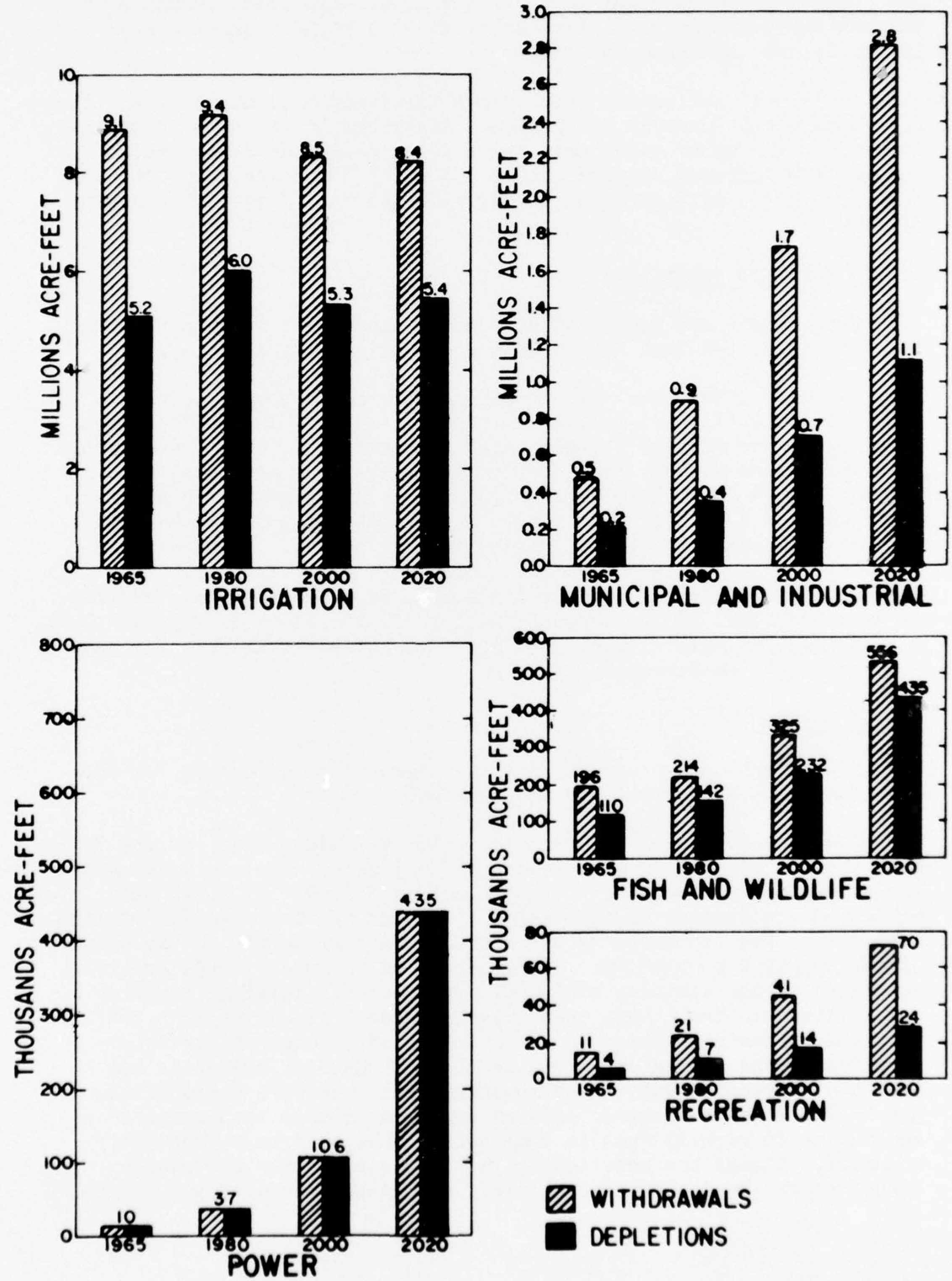
PROJECTED REGIONAL WATER REQUIREMENTS



1/ Excluding Colorado River mainstem evaporation, losses estimated to be 1.2 million acre-feet annually.

FIGURE D-3

PROJECTED REGIONAL WATER REQUIREMENTS BY USES



REQUIREMENTS

One of the most vital needs of the Lower Main Stem Subregion is the municipal and industrial water needs of a rapidly growing population in the Las Vegas, Nevada, area.

Additional irrigation development is expected to occur within the Fort Mohave and Colorado River Indian Reservations which would utilize Colorado River water under existing water rights. It is estimated that the water withdrawal requirement of 3.0 million acre-feet in 1965 will increase to 3.4 million acre-feet by 1980 and to 3.8 million acre-feet by 2020.

Little Colorado Subregion

The present and projected withdrawal and depletion requirements for the Little Colorado Subregion are summarized in Table D-7.

The most vital needs of the Little Colorado Subregion are: to supply additional water to its two major cities of Flagstaff, Arizona, and Gallup, New Mexico; to help maintain economic stability and to provide for future growth; to stabilize the present agricultural economy through a more dependable water supply; to provide greater employment opportunities for its predominantly rural Indian population through further development of the tourist industry, to attract outdoor recreationists, and to encourage development of light industry. The water supply is adequate on a subregional basis but is poorly distributed with respect to the areas of need. Additional water for municipal, industrial, and agricultural uses needs to be made available for several areas in the Subregion.

Gila Subregion

The present and projected water withdrawal requirements for the Gila Subregion are summarized in Table D-8.

The Gila Subregion is the major water deficient area of the Region. Even though 2.5 million acre-feet of ground water were mined in 1965, the apparent water requirements were not satisfied. By 2020, the depletion requirement is expected to increase by more than 2.1 million acre-feet. The increased requirements are due primarily to the needs of an expanding population. The majority of the water needs are concentrated in the vicinity of Phoenix and Tucson. Existing supplies are utilized to the extent that only infrequent floods produce outflow from the Subregion. There is a critical need to augment the water supplies of the Subregion to reduce the ground-water overdraft and to meet the increasing water requirements. The excessive overdrafting of ground water in the central Arizona area has caused land subsidence ranging up to several feet in some areas. Fissures have frequently occurred. Damage has resulted to farmland, irrigation structures, highways, railroads, buildings, etc., and unless overdrafting of ground

water is greatly reduced, the damaging effects can only increase. In many upstream areas of the Subregion, additional streamflow regulation is needed to eliminate seasonal irrigation water shortages; to provide additional upstream storage of water for increasing municipal and industrial uses; for the development of mineral resources; and for enhancement and management of fish and wildlife resources.

Land subsidence and fissures in an area of heavy ground-water overdraft.

Table D-5
Estimated Water Withdrawal and Depletion Requirements (1965 and Projected)
Lower Colorado Region

Unit: 1,000 Acre-Feet

Water Use	Withdrawals 1965	Withdrawals 1980	Withdrawals 2000	Withdrawals 2020	Depletions 1965	Depletions 1980	Depletions 2000	Depletions 2020
Reservoir Evaporation 1/	230	286	328	359	230	286	328	359
Mineral Development	105	178	264	357	51	89	135	185
Irrigation 2/	9,138	9,429	8,496	8,405	5,226	5,966	5,312	5,381
Municipal & Industrial	450	863	1,703	2,778	198	358	677	1,149
Recreation 3/	11	21	41	70	4	7	14	24
Fish & Wildlife	196	214	325	556	110	142	233	405
Power	10	37	106	435	10	37	106	435
Total	10,140 4/	11,026	11,264	12,960	5,829	6,885	6,805	7,938

1/ Exclusive of Colorado River Mainstream evaporation.

2/ Includes nonbeneficial consumptive use, estimated as 15 percent of irrigation requirement. Also includes estimated 600,000 acre-feet in-transit water losses in central Arizona area of Gila Subregion (1965 and 1980).

3/ Exclusive of lake and reservoir evaporation losses.

4/ 8,391,000 acre-feet actually withdrawn in 1965, includes 230,000 acre-feet reservoir evaporation.
Note: Columns do not necessarily add to total shown because of rounding.

Table D-6
Estimated Water Withdrawal and Depletion Requirements (1965 and Projected)
Lower Main Stem Subregion

Unit: 1,000 Acre-Feet

Water Use	Withdrawals				Depletions			
	1965	1980	2000	2020	1965	1980	2000	2020
Reservoir Evaporation 1/	32	49	50	50	32	49	50	50
Mineral Development	6	17	22	25	3	6	9	10
Irrigation 2/	2,682	2,771	2,434	2,396	1,107	1,402	1,365	1,456
Municipal & Industrial	116	323	684	954	48	125	257	394
Recreation 3/	3	7	15	24	1	2	5	8
Fish & Wildlife	140	152	220	292	100	113	167	211
Power	3	32	27	85	3	32	27	85
Total	2,983 4/	3,351	3,451	3,826	1,294	1,729	1,880	2,214

1/ Exclusive of Colorado River Mainstem evaporation.

2/ Includes nonbeneficial consumptive use, estimated as 15 percent of irrigation requirement.

3/ Exclusive of lake and reservoir evaporation.

4/ 2,352,000 acre-feet actually withdrawn in 1965, includes 32,000 acre-feet reservoir evaporation.
Note: Columns do not necessarily add to total shown because of rounding.

Table D-7
Estimated Water Withdrawal and Depletion Requirements (1965 and Projected)
Little Colorado Subregion

Unit: 1,000 Acre-Feet

Water Use	Withdrawals				Depletions			
	1965	1980	2000	2020	1965	1980	2000	2020
Reservoir Evaporation	39	41	45	45	39	41	45	45
Mineral Development	1	6	8	8	1	6	7	7
Irrigation 1/	136	141	129	120	59	72	72	72
Municipal & Industrial	20	37	63	105	9	16	26	41
Recreation 2/	1	3	5	8	1	1	2	3
Fish & Wildlife	6	11	16	31	4	9	13	24
Power	1	0	0	0	1	0	0	0
Total 3/	204 4/	239	266	317	113	145	164	192

1/ Includes nonbeneficial consumptive use, estimated as 15 percent of irrigation requirement.

2/ Exclusive of lake and reservoir evaporation.

3/ Excludes normal annual export of 15,000 acre-feet to Gila Subregion.

4/ 170,000 acre-feet actually withdrawn in 1965, includes 39,000 acre-feet reservoir evaporation.
Note: Columns do not necessarily add to total shown because of rounding.

Table D-8

Estimated Water Withdrawal and Depletion Requirements (1965 and Projected)

Gila Subregion

Unit: 1,000 Acre-Feet

Water Use	Withdrawals				Depletions			
	1965	1980	2000	2020	1965	1980	2000	2020
Reservoir Evaporation	159	196	233	264	159	196	233	264
Mineral Development	98	154	235	324	48	77	120	169
Irrigation 1/	6,320	6,517	5,933	5,889	4,060	4,492	3,875	3,853
Municipal & Industrial	315	503	955	1,719	141	217	394	714
Recreation 2/	6	11	22	39	2	4	7	13
Fish & Wildlife	50	50	89	234	6	20	52	170
Power	6	4	80	350	6	4	80	350
Total	6,953 3/	7,436	7,547	8,818	4,422	5,011	4,761	5,533

1/ Includes nonbeneficial consumptive use, estimated as 15 percent of irrigation requirement, also includes estimated 600,000 acre-feet in-transit water losses in central Arizona area of Gila Subregion (1965 and 1980).

2/ Exclusive of lake and reservoir evaporation.

3/ 5,869,000 acre-feet actually withdrawn in 1965, includes 159,000 acre-feet reservoir evaporation.
Note: Columns do not necessarily add to total shown because of rounding.

REQUIREMENTS

WATER QUALITY, POLLUTION CONTROL, AND HEALTH FACTORS

Salinity Control

At present the major water quality problem in the Lower Colorado Region is the high level of dissolved mineral solids in water supplies. This condition causes major problems to irrigated agriculture and to municipal and industrial users of water. Salinity increases in waters of the Lower Colorado Region are due principally to inputs from saline springs and the concentrating effects of consumptive use and evaporation.

Some 8.8 million tons of dissolved solids are transported by the Colorado River into the Region annually from the Upper Colorado Region according to long-term data for the period 1941-1966 1/. Two-thirds of the salt burden contributed by the Upper Colorado Region comes from natural sources and the remaining one-third of the salt burden at Lee Ferry comes from manmade sources, of which irrigation is of major significance. There will be substantial future increases in the salinity of the Colorado River unless a water quality program is initiated which would include both management and construction of major facilities.

Total dissolved solids concentrations were not projected for the Little Colorado Subregion nor in the Gila Subregion.

Salt balance in the central Arizona area may become a significant problem. Ground-water quality varies widely in composition and concentration. The transfer of water from the Colorado River to the central Arizona area will contribute substantial amounts of salt annually to the area. Because of the intense use of water having relatively high salinity, the nondegradability of the salts, and the absence of any significant outflow from the area, the ultimate repository for the dissolved salts will eventually be the ground water. Under these conditions, deterioration of ground-water quality is inevitable. To date, water quality degradation has occurred, but not on a uniform basis. The timing of the overall problem on an area-wide basis has not been predicted because of certain unknown complexities of the ground-water aquifers. Ways to improve salt balance in this desert southwest subregion should be included in future detailed studies.

1/ U. S. Department of the Interior, "Quality of Water, Colorado River Basin," Progress Report No. 4, January 1969. It should be noted that the 1941-1966 period of record is a period of below normal annual runoff rate. Runoff during average or higher years will carry a greater tonnage of dissolved solids.

Waste Water Treatment

Inadequately treated effluents from municipalities, manufacturing installations, mining and milling activities, and recreation areas have caused measurable stream pollution.

Adequate treatment of waste waters will be essential to assure maintenance of the water quality levels set forth in state water quality standards. To improve waste water quality, the backlog of construction for waste treatment facilities would have to be overcome. Construction of adequate treatment works should accompany all new waste producing developments.

In some critical areas, most notably in the Las Vegas, Nevada, area, there is a need to remove significantly large percentages of nutrients from municipal waste waters in order to abate the eutrophication problems resulting from Las Vegas Wash discharges to Lake Mead. Advanced methods of waste water treatment for the reclamation of municipal effluents for uses requiring high quality water will be needed in the Las Vegas, Phoenix, and Tucson metropolitan areas by 1980.

Erosion and Sedimentation

There is a need for land treatment measures that will reduce pollution caused by erosion and sedimentation. Erosion and deposition of sediments detract from land and water resources developments in the Region. Furthermore, the processes of erosion and sedimentation are factors in the chemical pollution of surface waters.

Sediment transport is the primary means whereby phosphorus applied to the lands as fertilizer reaches streams. Pesticides are washed from the land surface and carried into streams in runoff caused by rainfall and the application of excess irrigation water. Disturbed mining areas and tailings piles are sources of erosion and sedimentation and the subsequent contamination of waters by heavy metals tranported with the sediment. All of these pollution sources will need better surveillance and management programs to avoid degradation of water quality in the Region.

Air and Water Pollution and Vector-Borne Diseases

Available data indicate that rates of occurrence of potentially water-borne disease in the Lower Colorado Region are higher than are the national rates. Better epidemiological data are needed to assess what portion of these disease occurrences are due to water-borne pathogens.

Since infectious diseases are present in the Region, projected increases in the use of recreational areas, public water systems and

waste disposal facilities emphasize the need for improvement of vector control and drinking water quality control in recreational areas. Developers of land and water resources will need to place additional emphasis on minimizing the risk of spreading infectious diseases. Proper disposal of solid wastes will be needed to protect the public health and to prevent further pollution of land and water resources.

Projected growth in the manufacturing, mining, and thermal power production sectors emphasizes the need to prevent further air and water pollution from these sources. The expected use of nuclear fuels will make necessary the provision of adequate safeguards against hazards of radiological pollution.

LAND REQUIREMENTS

The economic projections formed a common base for determination of gross demands in terms of goods and services. The land requirements were based upon the translation of the water and related land resources to satisfy short- and long-term needs within the Region. In the determination of land requirements, assumptions were made that (1) to the extent practicable, land use will be based on sustained or increased production with minimum deterioration of the land and water resources and (2) the maximum application of the principle of multiple use will be employed.

Table D-9 compares land suitability and availability with projected requirements of land for all principal uses. It should be noted that, while there are sufficient suitable lands for each individual land use, even with widespread adoption of the multiple-use principle, not all of the requirements may be fulfilled.

Table D-9 - Comparison of Land Suitability and Availability with Projected Land Requirements

Unit: 1,000 Acres

	Lower Main Stem	Little Colorado	Gila	Total Region
Cultivation - irrigated				
Suitable	13,298	7,202	19,260	39,760
Suitable & Available (1965)	2,749	4,812	9,059	16,620
Use in 1965	324	40	1,421	1,785
1980 Requirement	379	44	1,440	1,863
2000 Requirement	382	44	1,456	1,882
2020 Requirement	403	43	1,387	1,833
Cultivation - nonirrigation				
Suitable	181	707	743	1,631
Suitable & Available (1965)	39	67	82	188
Use in 1965	8	23	-	31
1980 Requirement	7	21	-	28
2000 Requirement	6	17	-	23
2020 Requirement	6	13	-	19
Livestock Grazing				
Suitable	35,645	16,654	32,733	85,032
Suitable & Available (1965)	27,970	16,604	31,480	76,054
Use in 1965	27,970	16,604	31,480	76,054
1980 Requirement	26,769	16,429	30,541	73,739
2000 Requirement	24,017	16,263	29,622	69,902
2020 Requirement	20,608	16,057	29,142	65,807

Table D-9 - Comparison of Land Suitability and Availability (Continued) with Projected Land Requirements

Unit: 1,000 Acres

	Lower Main Stem	Little Colorado	Gila	Total Region
Timber Production				
Suitable	1,063	1,510	3,600	6,173
Suitable & Available (1965)	873	1,419	3,166	5,458
Use in 1965	873	1,419	3,166	5,458
1980 Requirement	845	1,396	3,117	5,358
2000 Requirement	838	1,333	2,982	5,153
2020 Requirement	831	1,284	2,929	5,044
Urban and Industrial				
Suitable	N/A 1/	N/A	N/A	N/A
Suitable & Available (1965)	N/A	N/A	N/A	N/A
Use in 1965	129	19	365	513
1980 Requirement	286	78	499	863
2000 Requirement	460	98	672	1,230
2020 Requirement	530	135	899	1,564
Outdoor Recreation (Designated)				
Suitable	N/A	N/A	N/A	N/A
Suitable & Available (1965)	N/A	N/A	N/A	N/A
Use in 1965	4,247	203	1,092	5,542
1980 Requirement	4,570	206	1,112	5,888
2000 Requirement	4,609	246	1,157	6,012
2020 Requirement	4,660	262	1,224	6,146
Wilderness (Classified)				
Suitable	2,000	58	1,400	3,458
Suitable & Available (1965)	2,000	58	1,400	3,458
Use in 1965	0	0	861	861
1980 Requirement	0	58	1,400	1,458
2000 Requirement	1,700	58	1,400	3,158
2020 Requirement	2,000	58	1,400	3,458
Military & Related Uses				
Suitable	N/A	N/A	N/A	N/A
Suitable & Available (1965)	N/A	N/A	N/A	N/A
Use in 1965	3,652	21	453	4,126
1980 Requirement	N/A	N/A	N/A	N/A
2000 Requirement	N/A	N/A	N/A	N/A
2020 Requirement	N/A	N/A	N/A	N/A

Table D-9 - Comparison of Land Suitability and Availability (Continued) with Projected Land Requirements

Unit: 1,000 Acres

	Lower Main Stem	Little Colorado	Gila	Total Region
Mineral Production				
Suitable	N/A	N/A	N/A	N/A
Suitable & Available (1965)	N/A	N/A	N/A	N/A
Use in 1965	5	7	63	75
1980 Requirement	9	28	78	115
2000 Requirement	10	41	105	156
2020 Requirement	11	84	128	223
Fish & Wildlife (Designated) 2/				
Suitable	30,615	14,600	31,210	76,425
Suitable and Available (1965)	3,188	16	19	3,223
Use in 1965	3,188	16	19	3,223
1980 Requirement	3,326	47	173	3,546
2000 Requirement	5,330	226	1,619	7,175
2020 Requirement	12,680	476	1,864	15,020
Transportation and Utilities				
Suitable	N/A	N/A	N/A	N/A
Suitable & Available (1965)	N/A	N/A	N/A	N/A
Use in 1965	221	63	376	660
1980 Requirement	266	103	489	858
2000 Requirement	318	130	582	1,030
2020 Requirement	357	136	652	1,145
Flood Control 3/				
Suitable	N/A	N/A	N/A	N/A
Suitable & Available (1965)	N/A	N/A	N/A	N/A
Use in 1965	3	-	74	77
1980 Requirement	36	12	181	229
2000 Requirement	54	17	218	289
2020 Requirement	61	20	255	336
Water Yield Improvement				
Suitable	607	1,678	2,776	5,061
Suitable & Available (1965)	456	1,229	2,000	3,685
Use in 1965	4	50	60	114
1980 Requirement	39	115	200	354
2000 Requirement	49	240	600	889
2020 Requirement	79	411	804	1,294

1/ N/A signifies not applicable.

2/ Managed primarily for fish and wildlife; 1.4 million acres were not available for hunter use in 1965 because of access restrictions.

3/ Area required for structures, impoundments, flowage easements, and other necessary rights-of-way under the proposed program which does not meet all projected needs.

MINERAL REQUIREMENTS

Table D-10 summarizes the value added by the mining sectors in base year 1965, plus projections for 1980, 2000, and 2020.

Copper is expected to remain dominant in the Region's mineral industry continuing to comprise 60 to 65 percent of the total domestic copper production. The production growth trend is expected to remain at about the same rate as occurred from 1948 to 1966. The output of the byproducts of molybdenum, silver, and gold will parallel the copper output.

The increased requirements for sand and gravel would be related to the population growth and its subsequent needs for construction materials.

An upturn in uranium production is expected to occur within the economic boundaries of the Region. However, the majority of this expected production would be outside the hydrologic boundaries of the Region.

Table D-10
Estimated Value Added of the Mining Sectors by Subregions for the Modified OBE-ERS Level of Development, 1965, 1980, 2000, and 2020

	Value Added (Million 1960 Dollars)			
Subregion	1965	1980	2000	2020
Lower Main Stem	16.0	54.2	66.0	80.1
Little Colorado	49.0	410.5	359.7	311.7
Gila	252.3	315.7	421.2	503.4
Lower Colorado Economic Region	317.3	780.4	846.9	895.2

LAND TREATMENT AND MANAGEMENT

An effective land treatment and watershed management program will be required to prevent loss of productive capacity of regional lands due to erosion and infertile overwash to improve quantity and quality of water supplies and to reduce peak runoff. Such a program will need to consider ways of using a larger percentage of precipitation, improving fish and wildlife habitat, increasing forage production, providing recreational opportunities, and providing protection from fire, overgrazing and other factors which would affect the ecological balance.

An appraisal of future land treatment and management requirements was made assuming that all land use will be based on sustained or increased production without deterioration of the land and water resources. In determining growth factors, consideration was given to such basic elements as population growth and distribution, expansion of employment opportunities, increased income, and agricultural and other land resource production trends.

The growth factors for items of damage related to agriculture were based on projections of total realized gross farm income. For items of damage other than agricultural, growth factors developed from population, income, and productivity projections were used to estimate future damage on the basis that these would reflect the increase in production and consumption of goods and services, changes in levels of capital development, and changes in land use.

In 1965, there were about 60 million acres within the Region in need of land treatment for erosion control and sediment yield reduction. The average annual damage based on the 1965 level of development on this acreage from this source is estimated to be $6.7 million. Assuming no additional erosion control measures were installed, the average annual damage would increase to $24.1 million by 2020 (see Table D-11).

Table D-11
1965 and Projected Average Annual Erosion Damage
(with the 1965 Erosion Control Program in Effect)
Lower Colorado Region

Unit: $1,000,000

Subregion	1965	1980	2000	2020
Lower Main Stem	1.5	2.9	4.9	7.0
Little Colorado	1.2	1.5	2.1	2.8
Gila	4.0	6.2	9.6	14.3
Region	6.7	10.6	16.6	24.1

REQUIREMENTS

Control of wildfire is basic to the development and utilization of nearly all resources, activities, and uses of the forest and rangelands. The agencies and organizations responsible for protection of the forest and rangelands from damage by wildfire must continue to expand their technology and methods for prevention and suppression to keep in step with the increasing values of water and related land resources. Problems and responsibilities for wildfire protection and control are multiplying due to the development of small communities, expanding urban, industrial, and public use developments scattered throughout the forest and rangeland of the Region and increases in recreation uses. This trend is expected to continue through the projection period. Average annual damage and suppression and rehabilitation costs of wildfires were about $5.7 million in 1965; this figure is expected to increase to $20 million by 2020 (see Table D-12).

Table D-12
1965 and Projected Average Annual Wildfire Damage and Costs
(with the 1965 Fire Prevention Program in Effect)
Lower Colorado Region

Unit: $1,000,000

Subregion	1965	1980	2000	2020
Lower Main Stem	1.3	1.6	2.2	2.7
Little Colorado	0.6	0.8	1.1	1.4
Gila	3.8	6.0	9.6	15.9
Region	5.7	8.4	12.9	20.0

Projected water requirements indicate a need to increase water yield from watersheds to the maximum extent consistent with soil stability, economic feasibility, and wildlife and recreation considerations.

In many rangeland areas inadequate supplies and poor distribution of stockwater are major problems.

FLOOD CONTROL

A major part of the Region's presently developed urban area and productive cropland is on lands subject to periodic flooding. Most land having topography suitable for general development within the Region is subject to flooding whether near a defined stream or not. Some of the areas presently developed are now protected to some degree by flood control measures; however, most areas remain unprotected. It is expected that most future development, whether urban or agricultural, will need some degree of flood protection.

Future damages were determined by projecting current flood damages by the use of growth factors from data developed in the Economics Appendix. With protection at the 1965 level, the expansion of the economy and projected growth in the area subject to flooding would increase total annual flood damage to $310 million by 2020 as shown in Table D-13 and graphically illustrated in Figure D-4. The annual agricultural damages would increase from $21.3 million to $61 million and the nonagricultural damages would increase from $19.5 million to $249 million. The non-agricultural damages include $13 million urban damages in 1965 and $201 million in 2020.

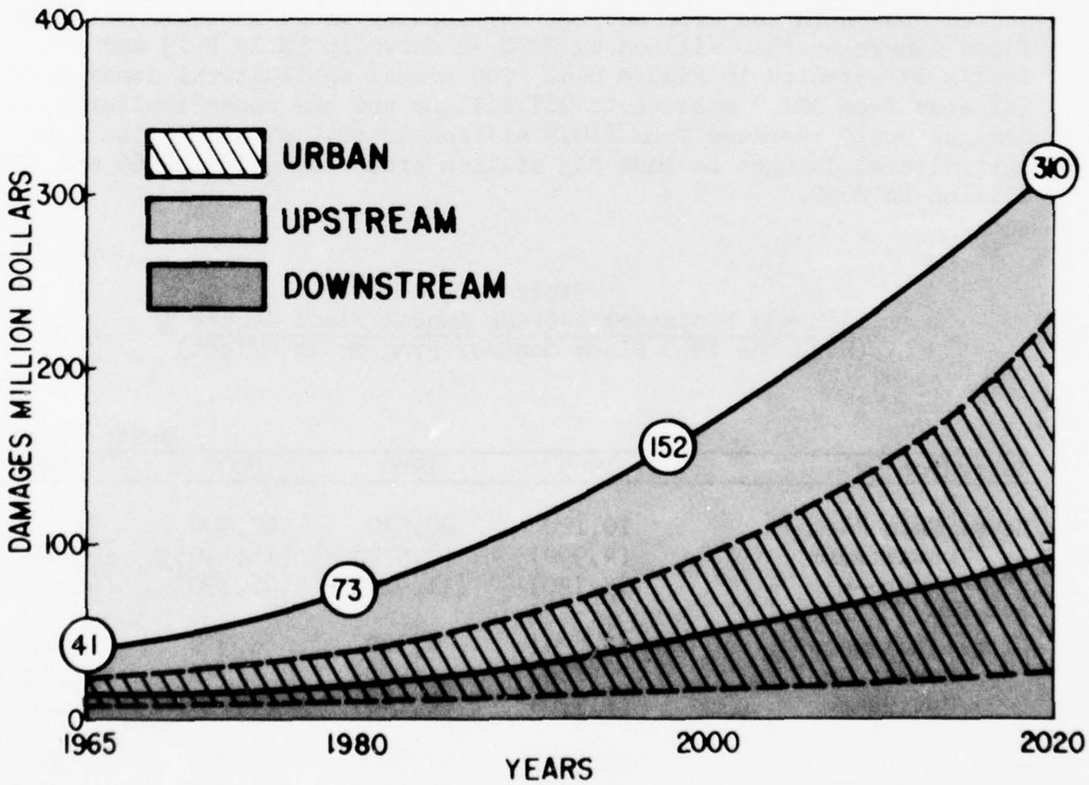
Table D-13
1965 and Projected Average Annual Flood Damage 1/
(With the 1965 Flood Control Program in Effect)

Unit: $1,000

Subregion	1965	1980	2000	2020
Lower Main Stem	10,120	20,530	42,980	77,000
Downstream	(4,990)	(8,570)	(16,590)	(28,300)
Upstream	(5,130)	(11,960)	(26,390)	(48,700)
Little Colorado	2,430	4,360	8,300	17,100
Downstream	(100)	(220)	(570)	(1,530)
Upstream	(2,330)	(4,140)	(7,730)	(15,570)
Gila	28,200	47,960	100,370	215,900
Downstream	(6,760)	(11,230)	(24,210)	(52,460)
Upstream	(21,440)	(36,730)	(76,160)	(163,440)
Total Region	40,750	72,850	151,650	310,000
Downstream	(11,850)	(20,020)	(41,370)	(82,290)
Upstream	(28,900)	(52,830)	(110,280)	(227,710)

1/ Refer to the Flood Control Appendix for more detailed information on the total flood damage problem and the Watershed Management Appendix for the upstream portion of this problem.

FIGURE D-4
PROJECTED ANNUAL FLOOD DAMAGES WITHOUT ADDITIONAL FLOOD CONTROL MEASURES



IRRIGATION AND DRAINAGE

The Lower Colorado Region has over 36 million acres suitable for irrigated agriculture of which only about 5 percent is projected to be utilized for crop production. The paucity and high cost of water in this semiarid region, where irrigation is a necessity for crop production, are expected to limit future agricultural development.

Irrigated agriculture is an integral part of the Region's economy upon which many other economic sectors depend either directly or benefit indirectly. Agriculture also provides limited employment opportunities to a segment of the Region's unskilled population. Part-time employment is also available to students during summer months. The Region is an important supplier of many of the Nation's agricultural products such as citrus fruit, winter vegetables, and long-staple cotton.

Projections indicate that about 204,000 acres of land presently developed for irrigation will be converted to urban development by the year 2020. Expected new land development for irrigation during the study period would include: lands in 14 Indian Reservations, small acreages in Nevada and Utah, and land in outlying ground-water basins principally in Arizona and New Mexico.

The increasing costs of irrigation water will encourage more efficient use of available water. New land development plus increased technology and limited life of structures will require continued installation of onfarm irrigation water management measures.

Although drainage is not considered a major problem in the Lower Colorado Region, local problems do continue to materialize in connection with irrigation. These problems are usually caused by one or more of several factors and often are slow in development.

With future importation to the Gila Subregion, agricultural drainage will increase substantially. Drainage systems will be required to collect this water. It is anticipated that about 69,000 acre-feet will be collected by 1990 and collection will approach 309,000 by the year 2020.

Drainage water collection will not only protect agricultural lands but also will provide water for reuse.

Table D-14 summarizes the anticipated land use and irrigation agriculture and Table D-15 summarizes water requirements and development needs.

Table D-14
Lower Colorado Region
Summary of Farm Irrigation Development

Unit: 1,000 Acres

Subregion (Hydrologic)	Year 1965	1980	2000	2020
Irrigated 1/				
Region	1,315	1,488	1,579	1,613
Lower Main Stem	293	360	373	403
Little Colorado	28	34	36	36
Gila	994	1,094	1,170	1,174
Double Cropped 2/				
Region	125	142	151	154
Lower Main Stem	26	33	34	37
Little Colorado	0	0	0	0
Gila	99	109	117	117
Planted, Not Harvested				
Region	73	18	16	15
Lower Main Stem	15	2	2	2
Little Colorado	2	11	9	6
Gila	56	5	5	7
Idle or Fallow 3/				
Region	374	292	225	160
Lower Main Stem	41	32	25	18
Little Colorado	6	5	3	3
Gila	327	255	197	139
Roads, Farmsteads, Canals 4/				
Region	80	87	92	95
Lower Main Stem	14	20	20	22
Little Colorado	2	1	2	2
Gila	64	66	70	71
Total Developed Area in Farms 5/				
Region	1,644	1,725	1,745	1,714
Lower Main Stem	312	379	384	406
Little Colorado	36	40	41	40
Gila	1,286	1,306	1,320	1,268
Harvested Acres 6/				
Region	1,242	1,470	1,563	1,598
Lower Main Stem	278	358	371	401
Little Colorado	26	23	27	29
Gila	938	1,089	1,165	1,168

1/ Irrigated acres including double cropping.
2/ Ten percent of total harvested exclusive of Little Colorado Subregion.
3/ Includes idle land in skip-row cotton production, plus a decrease of 1 percent per year from the 1965 base acreage of idle and fallow.
4/ Approximately 6 percent of total developed irrigated land.
5/ Summation of net irrigated cropland, farmsteads, farm roads and farm canals, and idle and fallow.
6/ Irrigated acres less planted, not harvested.

Table D-15
Irrigation and Drainage Water Requirements and Development Needs

	1965	1980	2000	2020
Water Requirements (1,000 A.F.)				
Water Requirements				
Depletions	4,024	4,666	4,829	4,893
Lower Main Stem	964	1,219	1,241	1,324
Little Colorado	51	62	66	66
Gila	3,009	3,385	3,522	3,503
Withdrawals	9,138	9,429	8,496	8,405
Lower Main Stem	2,682	2,771	2,434	2,396
Little Colorado	137	141	129	120
Gila	6,319	6,517	5,933	5,889

	1965	1966-1980	1981-2000	2001-2020
Development Needs (1,000 Acres)				
Drainage Needs 1/				
Lower Main Stem	210	67	18	38
Little Colorado	--	--	1	1
Gila	2	1	13	49
Rehabilitation of Existing Irrigation Distribution System 2/				
Acreage Served	293	429	--	--
Lower Main Stem	131	103	--	--
Little Colorado	2	6	--	--
Gila	160	320	--	--
Development of New Irrigation Distribution Systems 3/		347	596	132
Lower Main Stem	--	127	17	34
Little Colorado 4/	--	7	3	1
Gila	--	213	576	97
Irrigation Water Management 5/				
Lower Main Stem	--	128	207	208
Little Colorado	--	10	13	13
Gila	--	435	581	561

1/ Group drainage needs.
2/ Requirement to deliver water to farm.
3/ Includes replacement for irrigated area utilized in urban expansion.
4/ It is assumed that about 50 percent of the irrigated area will not be included in an organized district.
5/ Acreage needing rehabilitation and development of onfarm irrigation facilities for more efficient water management.

MUNICIPAL AND INDUSTRIAL WATER

A projected 370 percent increase in population, sixteenfold increase in the value of manufacturing output, fifteenfold increase in the economic activity in the trade and services sectors, and rising water-use rates by the Region's Indian and other rural residents are the major reasons for the tremendous growth of municipal and industrial water requirements shown on Table D-17. When compared to 1965 requirements, the 2020 depletions and withdrawals will require increases of 0.9 million and 2.3 million acre-feet per year, respectively.

As shown by Table D-16, the increase in livestock water requirement will be greater than 0.02 million acre-feet by 2020. The projected increase in range livestock is slight. Feeder livestock, on the other hand, are projected to increase significantly over the study period.

Table D-16
Livestock Water Requirements 1/
for the Modified OBE-ERS Projections

State/Subregion	1965	1980	2000	2020
Arizona	3,400	4,400	5,500	6,800
Nevada	300	400	500	600
Utah	600	700	900	1,100
Lower Main Stem	4,300	5,500	6,900	8,500
Arizona	1,700	1,700	1,800	1,800
New Mexico	500	500	600	600
Little Colorado	2,200	2,200	2,400	2,400
Arizona	9,500	16,500	20,800	26,100
New Mexico	900	1,600	2,100	2,600
Gila	10,400	18,100	22,900	28,700
Arizona	14,600	22,600	28,100	34,700
Nevada	300	400	500	600
New Mexico	1,400	2,100	2,700	3,200
Utah	600	700	900	1,100
Regional Total	16,900	25,800	32,200	39,600

1/ Includes only consumption by animals. Evaporation from stock watering ponds is included in the reservoir evaporation totals shown in the Water Resources Appendix. Assumes withdrawal = depletion. Water requirements are based on hydrologic subregions and expressed in acre-feet per year.

Table D-17
MUNICIPAL AND INDUSTRIAL WATER SUPPLY REQUIREMENTS 1/
FOR THE MODIFIED OBE-ERS PROJECTIONS

State/Subregion	1965 Withdrawal	1965 Depletion	1980 Withdrawal	1980 Depletion	2000 Withdrawal	2000 Depletion	2020 Withdrawal	2020 Depletion
Arizona	30,800	12,100	39,100	14,700	50,900	18,800	73,000	29,700
Nevada	76,100	30,000	272,300	102,300	618,400	228,600	861,700	350,800
Utah	4,400	1,800	6,300	2,400	8,100	3,000	11,100	4,500
Lower Main Stem	111,300	43,900	317,700	119,400	677,400	250,400	945,800	385,000
Arizona	13,700	5,200	26,600	10,500	44,500	17,000	67,000	25,500
New Mexico	3,600	1,400	7,700	3,000	16,300	6,300	35,400	13,400
Little Colorado	17,300	6,600	34,300	13,500	60,800	23,300	102,400	38,900
Arizona	302,900	129,700	481,800	197,600	925,000	367,700	1,677,900	680,400
New Mexico	1,800	800	3,300	1,400	7,300	2,900	12,700	5,100
Gila	304,700	130,500	485,100	199,000	932,300	370,600	1,690,600	685,500
Arizona	347,400	147,000	547,500	222,800	1,020,400	403,500	1,817,900	735,600
Nevada	76,100	30,000	272,300	102,300	618,400	228,600	861,700	350,800
New Mexico	5,400	2,200	11,000	4,400	23,600	9,200	48,100	18,500
Utah	4,400	1,800	6,300	2,400	8,100	3,000	11,100	4,500
Region Total	433,300	181,000	837,100	331,900	1,670,500	644,300	2,738,800	1,109,400

1/ Does not include livestock water use. Water requirements are based on hydrologic subregions boundaries and expressed in acre-feet per year.

RECREATION

Outdoor recreation demand estimates were based on analysis of 20 recreation activities with consideration given to such factors as increasing leisure time, greater mobility, more disposable income and other social aspects which affect total anticipated outdoor recreation participation.

The total demand for outdoor recreation is projected to increase over sixfold between 1965 and 2020. The greatest recreation pressures are expected to be exerted on resources in the Gila Subregion because of the present and projected population.

About 70 percent of the total recreation demand is urban oriented which means that this demand should be supplied within an hour travel time of the origin point of the recreation participant. Total recreation demand is summarized by the time frame for each subregion in Table D-18. Figure D-5 graphically illustrates regional requirements.

Of the total projected recreation demand about 27 percent is "Water Based." Table D-19 shows the water-associated recreation demand by time frame for each subregion.

Table D-18
1965 and Projected Total Annual Recreation Demand
Lower Colorado Region

Unit: Million Recreation Days

Subregion	1965	1980	2000	2020
Lower Main Stem	41.6	92.4	193.6	313.1
Little Colorado	19.4	35.9	63.2	101.1
Gila	77.2	139.3	283.0	503.4
Region	138.2	267.6	539.8	917.6

Table D-19
1965 and Projected Annual Water Based Recreation Demand
Lower Colorado Region

Unit: Million Recreation Days

Subregion	1965	1980	2000	2020
Lower Main Stem	10.9	25.0	52.8	85.5
Little Colorado	5.1	9.6	17.0	27.5
Gila	22.0	38.9	78.3	139.0
Region	38.0	73.5	148.1	252.0

FIGURE D-5
PROJECTED RECREATION DEMAND

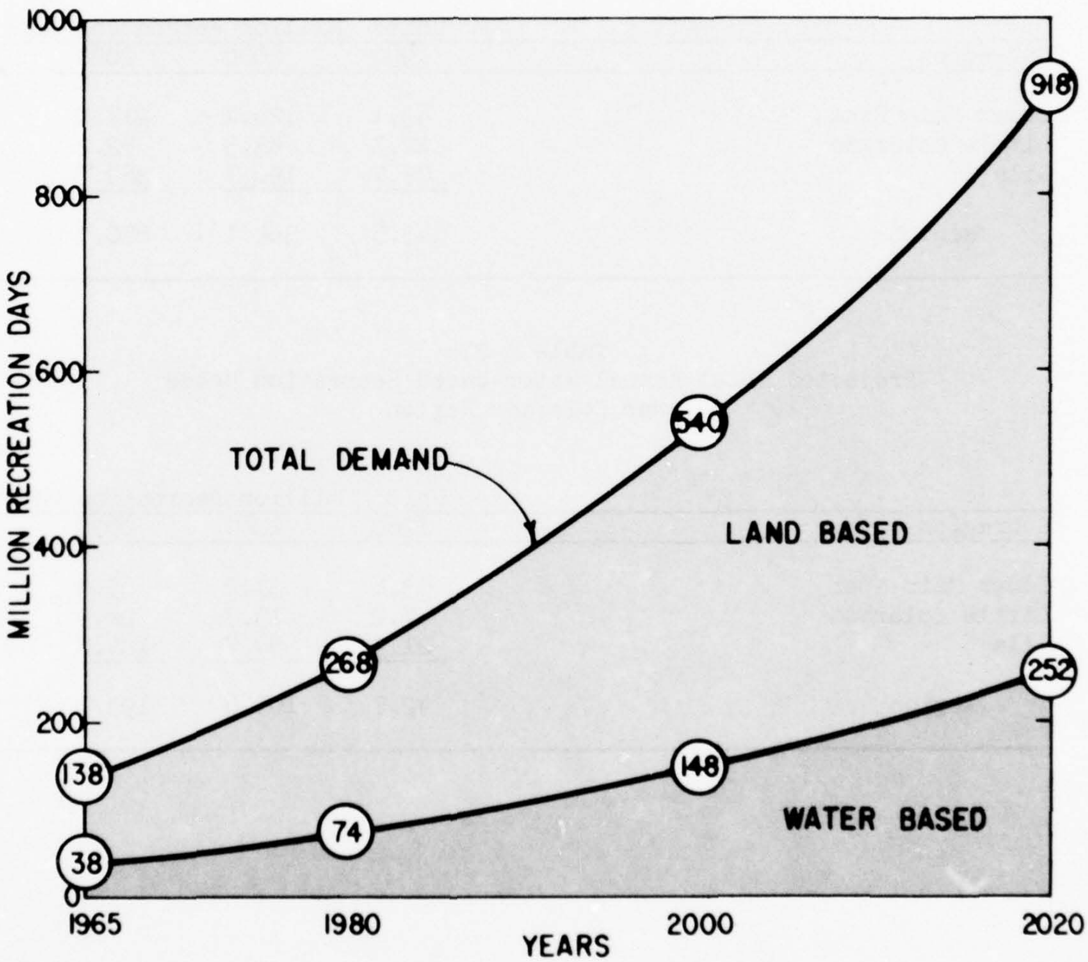


Table D-20 shows the total recreation needs by time frame for each subregion while Table D-21 shows total water-based recreation needs. Recreation need is that part of projected recreation demand which the 1965 resource supply would not satisfy.

Table D-20
Projected Total Annual Recreation Needs
Lower Colorado Region

Unit: Million Recreation Days

Subregion	1980	2000	2020
Lower Main Stem	43.1	124.1	217.8
Little Colorado	22.7	43.3	72.2
Gila	77.7	196.7	380.7
Region	143.5	364.1	670.7

Table D-21
Projected Total Annual Water-based Recreation Needs
Lower Colorado Region

Unit: Million Recreation Days

Subregion	1980	2000	2020
Lower Main Stem	13.6	37.2	65.4
Little Colorado	7.2	13.7	22.9
Gila	21.9	54.7	104.8
Region	42.7	105.6	193.1

FISH AND WILDLIFE

The demand for sport fishing and hunting will grow with increasing human population, leisure time, mobility, and affluence. Demand varies directly with human population, and good quality fishing and hunting opportunities vary inversely with the population. The bulk of the present and projected demand originates from the population centers of Phoenix, Tucson, Las Vegas, Gallup, and Yuma. Areas of high use include Lakes Mead and Mohave on the Colorado River, the Mogollon Rim area from Flagstaff east into New Mexico, and the Gila and San Francisco River areas in New Mexico.

The projected fish and hunting demand for 1980, 2000, and 2020 was determined by adjusting upward the 1965 per capita rate, taking into account the population's increasing leisure time, greater mobility, increasing life expectancy, and earlier retirements. The projected demand for 1980, 2000, and 2020 is dependent upon population densities, changes in urban-rural populations, and changes in availability of opportunity. The projected demand for sport fishing is presented in Table D-22 and the projected demand for sport hunting is presented in Table D-23. Figure D-6 illustrates the projected regional requirements.

Bird and animal watching, photography, and related activities are an important segment of wildlife-oriented recreation. It is estimated that the time and money spent on equipment, transportation, lodging, and related items associated with observing fish and wildlife resources eventually may approach that expended by hunters.

There are 12 species of fish and wildlife within the Region that are classified as "endangered." Endangered species are those so few in numbers or so threatened by present circumstances as to be in danger of extinction. There are 6 species classified as "rare," 23 peripheral species, and 13 species whose status is undetermined. The preservation of habitat for these species is a critical need.

For detailed information on fish and wildlife see the Fish and Wildlife Appendix.

FIGURE D-6

PROJECTED SPORT FISHING AND HUNTING DEMANDS

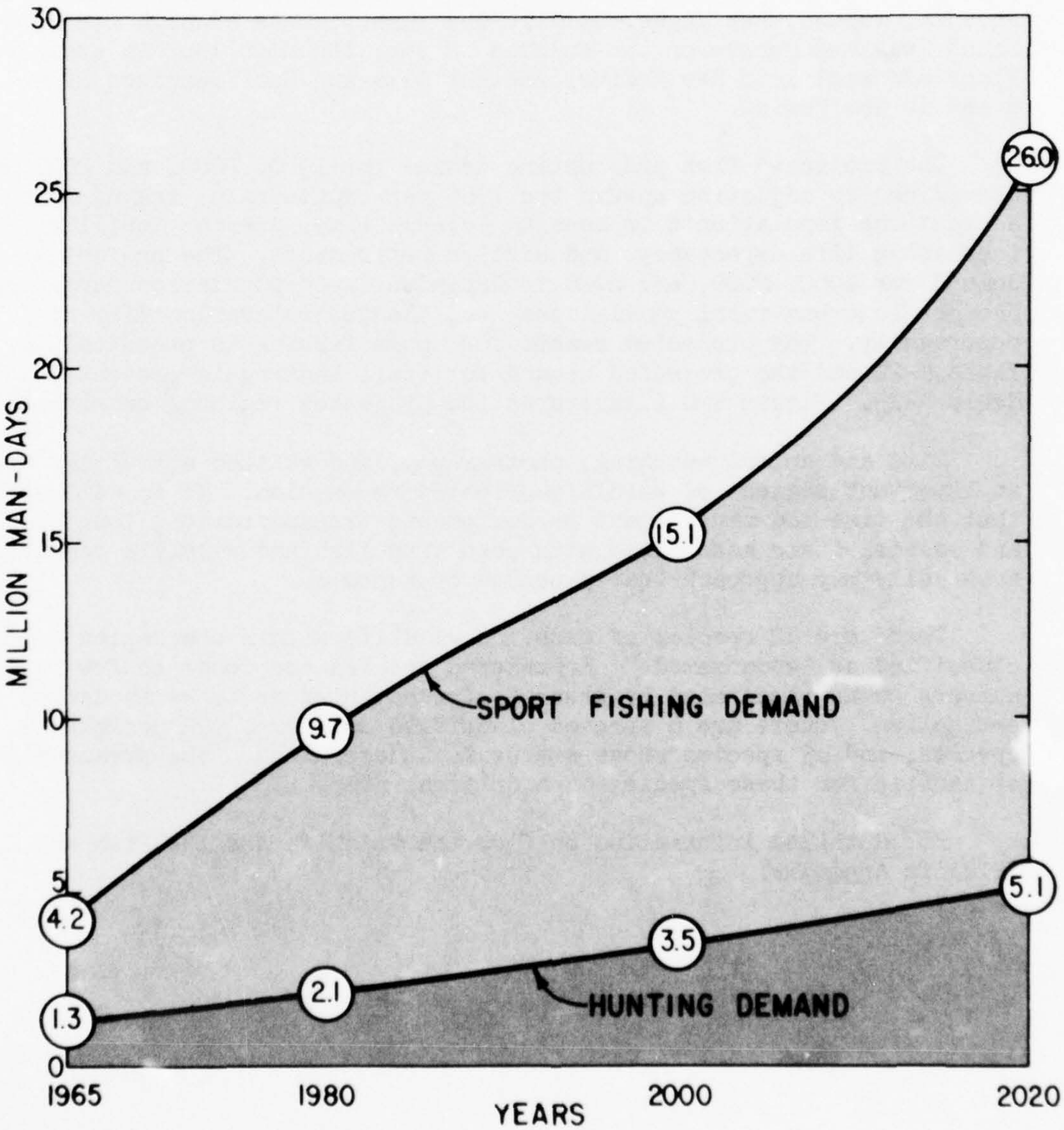


Table D-22
Sport Fishing: 1965 and Projected Demand
Lower Colorado Region

Subregion and Region	Demand (Million Man-Days)			
	1965	1966-1980	1981-2000	2001-2020
Lower Main Stem				
Cold Water	0.4	0.8	1.6	2.8
Warm Water	1.8	3.5	6.2	9.3
Subtotal	2.2	4.3	7.8	12.1
Little Colorado				
Cold Water	0.2	0.5	0.6	1.0
Warm Water	0.1	0.2	0.2	0.2
Subtotal	0.3	0.7	0.8	1.2
Gila				
Cold Water	0.6	1.8	2.0	4.0
Warm Water	1.1	2.9	4.5	8.7
Subtotal	1.7	4.7	6.5	12.7
Region				
Cold Water	1.2	3.1	4.2	7.8
Warm Water	3.0	6.6	10.9	18.2
Total	4.2	9.7	15.1	26.0

Table D-23
Sport Hunting: 1965 and Projected Demand
Lower Colorado Region

Subregion and Region	Demand (1,000 Man-Days)			
	1965	1966-1980	1981-2000	2001-2020
Big Game				
Lower Main Stem	130	316	592	777
Little Colorado	76	112	147	196
Gila	316	404	687	1,056
Lower Colorado Region	522	832	1,426	2,029
Small Game				
Lower Main Stem	113	274	515	675
Little Colorado	62	91	119	158
Gila	574	780	1,245	1,914
Lower Colorado Region	749	1,145	1,879	2,747
Waterfowl				
Lower Main Stem	24	57	107	141
Little Colorado	7	11	15	20
Gila	42	58	93	143
Lower Colorado Region	73	126	215	304

ELECTRIC POWER REQUIREMENTS

The electric power requirements in the Region increased rapidly during the period 1955 through 1965. The average annual growth rate was 9.5 percent which is about 1.5 times the national growth rate of 6.6 percent for this period.

Power requirements are estimated to average an 8.2 percent annual increase for the period of 1965-1980, 7.6 percent for 1980-2000, and 5.7 percent for 2000-2020.

Estimates of future power requirements were based on analyses of classified sales data and population data for the power systems of the Region. Apparent trends were extended into the future, modified, and adjusted to take account of information on economic development expected in the Region. The resulting estimates were compared with similar estimates supplied by the power systems of the Region, and further adjustments made. No attempt was made to forecast cyclical variations in the demand for electric power even though these occurred in the past and will no doubt recur in the future.

Projected electric utility requirements are shown on Table D-24.

Table D-24
Projected Electric Utility Requirements

	Energy (gwh)	Peak Demand (mw)	Load Factor (%)
1980	43,350	8,331	59.4
2000	186,110	35,767	59.4
2020	564,540	108,494	59.4

Regional 1965 and projected power generating capacities and related cooling water requirements are shown in Table D-25.

Table D-25
Generating Capacities and Water Requirements 1/

	1965	1980	2000	2020
Generating Capacities (mw)	4,300	7,000	31,500	116,000
Water Requirements (1,000 A.F.)	10	37	106	435

1/ Depletions = withdrawals.

MEANS OF SATISFYING REQUIREMENTS

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CHAPTER E - MEANS OF SATISFYING REQUIREMENTS

WATER SUPPLY

The water supply problems of the Region are extremely complex in nature and extensive in scope. Though some localized problems may be solved through developments of somewhat limited scope, the regional water problems must be approached with the broadest interpretation of multipurpose concepts. The objectives of the regional program are first, to achieve the most efficient use of existing regional water supplies; second, to ascertain the additional quantities of water needed in future time frames; and finally, to determine the potential means by which these needs may be supplied.

All means employed in the framework program for the satisfaction of water requirements, as well as the other requirements, must comply with the National Environmental Policy Act of 1969, Public Law 91-190 (83 Stat. 852).

The primary objective during the time period 1965 to 1980 is to forestall the impending water crisis through construction of those projects already authorized. The next objective must be an intensive study of all alternative means of augmenting the Region's existing water supply with increments sufficient to meet the increasing demand and to reduce or eliminate the present ground-water overdraft. An active construction program is urgently needed now to meet the 1980 water requirements and is, in fact, at least 10 years behind schedule.

There are several potential means which must be considered to either increase the Region's fresh water supply or to decrease sub-regional deficits. These means include transfers of water from areas of surplus within the Lower Colorado Region, importation of water from areas of surplus outside the Region (Alaska or Pacific Northwest), desalting sea water (Pacific Southwest), desalting brackish water (areas where ground water is plentiful but brackish), precipitation management (cloud seeding), water conservation (elimination of waste and improved regulation), water salvage (reuse after treatment), and increasing water yield (through land treatment). Another potential water source worthy of consideration and further study is the geothermal fields underlying parts of the Region. Consideration should also be given to reducing water requirements by methods such as increased farm crop yields (thereby reducing land and related water requirements for a given level of production), evaporation reduction, increased irrigation efficiency, and reduced municipal and industrial per capita use. Among these means, desalting of sea water and importation of water from areas of surplus outside the Pacific Southwest area appear to have primary

potential for supplying the large quantities of water needed. Legislative constraints, imposed by the "Guidelines for Framework Studies" - Water Resources Council, preclude consideration of the latter source for this comprehensive plan. A combination of the several approaches could reduce importation requirements, and these potential means should also be considered.

Conservation storage in reservoirs presently constructed or authorized for construction will provide control to the extent that little or no water will leave the Region. Some additional storage is needed to provide a regulated water supply for areas upstream from the San Carlos Reservoir in the Gila Subregion. Since all Gila River water is presently overappropriated and utilized, additional water must be imported to the downstream area. In the Little Colorado Subregion, upstream storage could provide some regulation and make additional water available for local uses. This potential is limited, however, by the lack of reservoir sites, poor water quality, and limited water supplies in the areas of need.

There is evidence indicating the presence of untapped ground water in storage in the mountain regions of north central Arizona. This could provide a source for a transbasin diversion to the Gila Subregion. Future study is needed to evaluate this potential source.

Other possible outlying (remote from area of need) ground-water basins should be evaluated as to their potential as a source of water for diversion to areas of deficiency. Though limited, these ground-water potentials could provide a temporary means of alleviating some of the ground-water overdraft until other means of augmentation become available.

Nearly all return flows in the Region are presently reused either directly or by recharge to ground water. Treated sewage water is used for industrial cooling and as irrigation water. Irrigation return flows make up part of downstream supplies that are eventually reapplied to crops. More extensive reuse of municipal and industrial effluents, after some form of tertiary treatment, will provide increasing amounts of water where practiced, thus reducing the total regional withdrawal requirement. Further work is needed to establish safe standards for, and suitable uses of, treated waste waters and to determine what conveyance and distribution systems will be required to deliver the reclaimed water.

WATER QUALITY, POLLUTION CONTROL, AND HEALTH FACTORS

The maintenance of desired levels of water quality will require control of the amount of pollutants reaching the water of the Region. Regional salinity measures will involve the suppression of salt discharges from saline springs and water management improvements aimed at minimizing the degradation of quality. Augmentation of surface sources could improve water quality depending on the amount and place of augmentation.

Salinity control measures should be incorporated into a basinwide water quality management scheme. Additional research and demonstration projects are necessary to establish the feasibility of various proposals for improvement. In some areas the desalination of surface and ground waters will be necessary to meet future needs.

Improvements in waste water treatment will reduce water pollution caused by the discharge of municipal and industrial effluents. Water quality standards should be met. Special attention to waste water treatment, in areas of intensive recreational use, would help provide the high quality water needed for recreational purposes. Advanced methods of waste water treatment could not only further reduce water quality problems, but would also provide an acceptable quality of water for agricultural, industrial, and recreational uses. Research would provide a better understanding of tertiary treatment methods and the suitability of reclaimed water for various uses.

Sediment is the greatest water pollutant, by volume. Sediment is produced by soil erosion, and erosion can be reduced. Sediment carries other water pollutants, such as organic wastes, inorganic chemicals, and infectious agents. Recommended practices and measures in the land treatment and management program for reduction of erosion and sedimentation would have beneficial effects on water quality. This type of pollution can also be reduced by better management in the use of agricultural chemicals.

The development of additional environmental control programs at all levels of government and increased support of present programs will provide improved protection of the public health from air, water, and vector-borne diseases. Improvements in environmental quality could be accomplished, in part, through the education of the populace to the needs of a properly controlled environment. Enforcement of state air and water quality standards,and compliance by Federal activities with Executive Order 11507, will be essential to the achievement of a better environment.

THE MEANS

Present potable water systems as well as waste water treatment works must be upgraded for the protection of the public health. Provision must be made for the adequate and safe disposal of solid and liquid wastes from future activities. Reporting and warning systems and emergency procedures for handling accidental discharges of hazardous materials should be developed.

LAND TREATMENT AND MANAGEMENT

An effective land treatment and management program must be designed to provide: protection of the resource base, more efficient production and water use, improved fish and wildlife habitat, enhanced recreation opportunities, increased and stabilized patterns of streamflow, reduction of sediment yield, more efficient urban development, and an overall enhanced living environment. It is essential that the land treatment and management program harmonize with all water and related resource development programs required to satisfy present and projected demands within the Region.

The program should include the analysis, protection, development, operation, and maintenance of the land, vegetation, and water resources of the Region necessary to avoid or minimize irreversible losses of the resources in order to preserve the freedom of choice for future resource users.

Cropland

Measures such as diversions, levees and dikes, channel improvement, floodways, and streambank protection should be considered for erosion, sediment, and runoff control on cropland. These contemplated measures are primarily for protection of the land and improvements and would include those measures which would not require group implementation but could be installed by the individual owner or operator. These features would be designed to maintain and/or improve the productivity of the land, reduce the sedimentation and erosion hazards, and to help keep soil losses within allowable limits. The practices would have a beneficial effect on water quality and would further the environmental quality objectives. Most of the water pollutants such as sediment, plant nutrients, and insecticides which could be carried to the watercourses by floodwaters would be retained on the land.

Rangeland

An accelerated land treatment and management program is necessary to satisfy the demands being placed upon rangelands. Areas of greatest concern are reduction of sediment yield, improvement of water quality and/or quantity, and protection of the ability of the land to produce. Land treatment measures designed to produce these effects will usually also benefit recreation, livestock forage, wildlife habitat, esthetics and other resources, uses, and services.

Means for consideration in developing an effective land treatment and management program on rangeland consist of (1) structural measures, such as grade stabilization, diversions, and terraces; (2) vegetative measures such as grass, tree or shrub plants; and (3) the orderly and

efficient use of water, land and other resources, and the protection of the environment.

Forest Land

Watershed protection, management, and treatment programs of forest lands are designed, implemented, and maintained to assure improved water quality, increase water yield, and improve runoff timing to provide optimum values for onsite and downstream uses.

Water of poor and unsatisfactory quality on the forest land usually results from poor watershed conditions. Improved land use practices can contribute substantially to improvement of watershed conditions and soil stability. In some cases, mechanical measures, including weed control and grass seeding, furrowing, trenching, gully plugs, stream channel riprapping and other stabilization measures will be required. Improved land use practices and appropriate mechanical measures applied to more than 11 million acres of forest land in the Region would result in decreasing the average annual sediment yield by more than 9 million tons.

Based on present research, it is estimated that 5.1 million acres of forest land in the Region could be managed to increase the average annual water yield by more than 1.1 million acre-feet during years of average precipitation. To date studies are inconclusive on the expected increase in water yield and possible effects on other land resources and uses of this type of management. Included in the total area are an estimated 261,000 acres of phreatophytes along the main streams of the Region with an estimated potential of about 624,000 acre-feet of increase in water yield annually.

Timber management programs for mixed conifer types provide for natural or artificial regeneration to be achieved through clear cutting in small blocks or strips. The ponderosa pine type will be managed on a "seed tree" or "shelter wood" silvicultural system. Treatment for pinyon-juniper, chaparral and riparian types of forest lands would be a partial conversion to grass and forbs, leaving areas of tree and brush cover for wildlife habitat. This proposed treatment for increasing water yield if properly planned and carried out will improve the habitat for most wildlife, increase domestic livestock forage production and stabilize the soils, thereby, reducing erosion and sediment production.

Urban and Other

Vegetative cover information, seeding and other methods are available to reduce sediment yield from urban areas. New construction sites can be protected by plastic, undisturbed native vegetation, temporary vegetation and other means.

Esthetics and quality of runoff water can be improved and protection of the soil resource can be effected by control of soil erosion from streets and alleys by seeding and stabilizing of road cuts, utility rights-of-way, and other disturbed areas.

FLOOD CONTROL

Satisfaction of regional needs for flood control can be accomplished by structural and nonstructural measures. Structural measures would control the flow of water and would include reservoir storage for floodwater and sediment, levees, and channel improvement. Nonstructural measures would prevent future flood damage through regulation of the flood plain by implementing flood plain zoning and application of flood proofing techniques.

Flood control projects would be designed to regulate the flow so that flood damages are kept to a minimum. Flow regulation would be accomplished by constructing reservoirs with flood control storage or levee and channel improvement works separately or in combination. In a reservoir with flood control storage, floodwaters would be stored and later released at nondamaging rates. In levee and channel improvement projects, sufficient channel capacity to carry peak flows would be provided by dredging, clearing, and straightening the waterway; by building a channel with smooth surface to improve flow characteristics; by constructing levees; by providing bypasses; or by some combination of these methods.

The nonstructural measures of floodway regulation would be aimed at managing development, whether subject to damage or not, that would adversely affect the passage of floodflow. Means available to communities to regulate development in the flood plain are zoning, subdivision regulations, building and health codes, tax concessions, and others.

Flood proofing methods would include a combination of structural changes and adjustments to structures already existing in the flood plain, and to new structures, where activities dependent upon a riverine location need some degree of protection.

Development of a national flood insurance program will enable interested persons to purchase insurance against losses, and it will identify floodprone areas, established flood-risk zones, and develop criteria for land management and use.

The flood-forecasting system should be improved by expansion of data measuring and reporting networks. This expansion would include more extensive use of telemetered soil moisture and precipitation

measuring devices in remote areas; the capability for satellite measuring of surface temperature fields, snow area and depth, and atmosphere temperature-moisture profiles; and increased radar coverage. Increased research is needed to develop better hydrologic models.

Widespread application of land treatment measures through watershed management will provide means for alleviating local erosion, sediment damages, and flood losses (in some situations preventing or reducing floodflows) and will complement the structural measures, particularly with respect to sediment problems. Bank erosion would be reduced or prevented by impounding floodwaters in reservoirs and by levee and channel improvement projects.

IRRIGATION AND DRAINAGE

To satisfy irrigation requirements listed in the preceding chapter, it will be necessary to develop some lands not presently irrigated. A portion of these will include lands that are now developed, but idle, while the remainder will encompass new lands.

It was assumed that all existing distribution systems would be rehabilitated with concrete lining and/or pipelines by 1980. In addition, new irrigation distribution systems would be required to deliver water to areas that are now served by pumped water and to the areas that will be needed for the projected irrigation increase and urban replacement.

Water management measures are means of meeting the needs for control and more efficient use of irrigation water and/or reducing the costs of irrigation. At the same time these practices maintain or improve the productive capacity of the soil and provide opportunity for increased yields through better water distribution and timeliness of operations. Measures such as land leveling, irrigation ditch lining, and converting from open ditches to pipelines should be considered in implementing this program.

By year 2020, additional drainage facilities will be required in the central Arizona area to collect an estimated 309,000 acre-feet of agricultural drainage water for disposal or for treatment and reuse.

MUNICIPAL AND INDUSTRIAL WATER

Augmentation of regional water supplies will be necessary to meet future municipal and industrial water requirements. There is presently practically no outflow from the Region and the existing water supplies

are reused either following treatment or by recycling through the ground-water reservoir. The importation of water into the Region would provide additional opportunity for the direct reuse of return flows through water reclamation facilities. Some water could probably be transferred from other uses, but this would result in increased deficiencies in such use sectors as agriculture, fish and wildlife, and recreation. The extent of water transfers would be limited by economic, legal, and institutional constraints.

Table E-1 summarizes regional problems and potential means of meeting the projected municipal and industrial needs.

Table E-1
Present and Potential M&I Problem Areas
and Probable Means of Satisfying Needs

Problem Area	Type of Problem	Timing of Problem	Probable Means of Satsifying Needs
Lower Main Stem Subregion			
Clark County, Nevada SMSA 1/	Quantity & Quality	2000	Development of Additional Supply; treatment.
Yuma, Arizona	Quality	1965	Central Softening Plant.
Little Colorado Subregion			
Holbrook-Winslow, Arizona	Quantity & Quality	1980	Development of Additional Supply.
Flagstaff. Arizona	Quantity	1980	Development of Additional Supply.
Gallup, New Mexico	Quantity & Quality	1965	Development of Additional Supply.
Gila Subregion			
Maricopa County, Arizona SMSA 1/	Quantity & Quality	1965	Establishment of Metro. Service; Direct Conversion of Irrigation to M&I; Treatment; Transfer of treated M&I waste water for irrigation supply.
Pima County, Arizona SMSA 1/	Quantity	1965	Direct Conversion of irrigation to M&I. Transfer of treated M&I waste water for irrigation supply.

1/ Standard Metropolitan Statistical Area.

RECREATION

The means for satisfying the recreation needs involve consideration of two basic alternatives. These two alternatives are: (1) developing a recreation plan that attempts to meet the recreation needs within the constraints of the existing legal, institutional, financial and physical framework, and (2) meeting the recreation needs by implementing changes in the existing legal, institutional, and financial framework.

The first alternative assumes that the historical trend of providing recreation opportunity by government entities and the private sector would continue into the future. Analysis of this historical trend indicates that only 37 percent of the total recreation development and acreage acquisition needs would be met by the year 2020. This means that 285 million recreation days out of 672 million would be satisfied, leaving an unmet need of 387 million recreation days.

The second alternative entailed an assessment of the various options available to government and private interests for meeting all recreation needs with primary consideration given to those options which could be most reasonably proposed.

Within the concept of the second alternative, most recreation needs would be met if the necessary legal, institutional, and financial constraints are removed or modified.

Specific means for satisfying recreation needs within the second alternative include Federal and state land use planning and zoning, expanded recreation grant programs, new tax and incentive proposals, new state funding arrangements, recreation programs for the disadvantaged, multiple use of existing lands and facilities, provisions for open space, new land acquisition proposals, legislation to open up new water areas to recreation use, and many other means. The Recreation Appendix recommends a plan of action which if implemented would provide the mechanism for government entities and the private sector to more fully meet future recreation needs.

Preservation of open space, wilderness, wild and scenic rivers, natural areas, and cultural aspects can be implemented through modification of some existing laws, and consideration of environmental issues in future project planning.

FISH AND WILDLIFE

Most species of fish and wildlife are very sensitive to the methods used in the development of the water and related land resources. As development within the Region occurs every effort should be made to maintain or improve the fish and wildlife habitat in order that projected demands for the use of these resources may be satisfied.

Fish

The development of an adequate water-resource base, consisting of multipurpose and primary-purpose impoundments, is necessary to satisfy the expected demand for fishing and associated uses. Primary-purpose fishing reservoirs, up to 200 surface acres in size, are proposed to help meet the demand for public fishing. These smaller lakes are more easily managed for maximum production while maintaining fishing quality for public benefit. In instances where reservoir development would be in conflict with established water rights, exchanges or purchase of water rights would be necessary.

Multipurpose reservoirs larger than 200 acres offer substantial opportunity to satisfy a portion of the demand for fishing and other water-oriented uses. Per acre use, however, is usually less intensive on the larger reservoirs. Planning of such impoundments must be fully coordinated to insure that all purposes, including fishery enhancement, are considered in project formulation.

Protection and enhancement of present and future water resources needed for fishing and associated uses would be helped by an intensified watershed protection and management program.

Adequate access, parking, and sanitary facilities must be provided to assure optimum use of the fishing habitat. Selected lakes and reaches of streams need facilities for intensive public use while other areas should be kept in a more primitive state. Appropriate zoning of certain reservoirs, sections of reservoirs, and reaches of streams could aid in meeting projected demand and in preserving the quality of the fishing experience.

Improvement of fishery management practices would assist in maintaining optimum conditions for sport fishing and associated uses. For instance, intensified lake rehabilitation will help in maintaining the ratio between game and nongame fish to yield the most productive sport fishing.

Fish propagating facilities to supplement natural reproduction will be required to satisfactorily stock available habitat and to

provide a more desirable quality of sport fishing and associated uses through the projection period.

Wildlife

The primary concern in satisfying the demands for wildlife resources is the preservation and improvement of existing habitat. In the Lower Colorado Region, most of the valuable wildlife habitat is on lands administered by public agencies, thus providing significant opportunities for further wildlife development. Satisfying a part of the demand for fish and wildlife resources is dependent upon improving the existing habitat.

Most importantly, satisfying future demands for fish and wildlife resources will necessitate that selected areas, consisting mostly of large tracts of public land, be managed to yield maximum fish and wildlife values. The areas would be managed with emphasis directed to the production of fish and wildlife, with appropriate consideration of compatible and/or complementary uses.

Many mangement methods are available to wildlife managers to satisfy future demands for wildlife-oriented activities. The methods vary from providing all habitat requirements artificially to emphasizing the management of wildlife on areas marginally suitable for other uses such as grazing.

In water-short areas of the desert where other habitat requirements are met, wildlife watering stations would be of significant value to most wildlife species. In areas where food and/or cover is limited, construction of water-spreading dikes along natural drainages would provide a natural irrigation which would increase growth of plants for both food and cover. These spreader dikes would also serve as water-collecting devices for wildlife watering facilities.

An intensified watershed protection and management program should be designed to protect the land resources required to satisfy the projected demand for sport hunting and associated uses. Fencing of high-value wildlife areas to exclude livestock would be beneficial in some cases.

The construction of access roads and trails into the remote areas of the Region would help in meeting the projected demand.

Federal lands that are prime wildlife habitat should be classified for retention in Federal ownership thus reducing the likelihood of introducing conflicting uses.

Many areas within the Region may be suitable for introduction of new wildlife species. Restocking of former range is a normal, accepted

practice by most wildlife agencies. The introduction of new wildlife species, however, can connote various difficulties. Introduction of big game species should only be accomplished following intensive investigation of both the animal and the habitat.

Elimination or moderation of currently existing unnecessary restrictions to hunting or other associated wildlife uses on some lands would also help in meeting the projected hunter demand.

Adjustment of the hunting seasons for certain species of wildlife, especially those species that migrate, could make available more opportunities for participation. Dispersion, as much as possible of the hunting seasons during the year for the different species, would be beneficial in providing additional hunting opportunities.

Construction and maintenance of marshes and ponds for open water, plus planting of crops to supply feeding areas, could help in meeting projected hunting demand by attracting and keeping waterfowl in the Region. Waterfowl habitat could be enhanced by providing management areas on selected existing and future reservoirs. Properly zoned management areas would reduce occurrence of conflicting activities. Management of these water-habitat areas would include surveillance and control of disease vectors such as mosquitoes and other insects.

ELECTRIC POWER

In Appendix XIV, it was assumed that thermal power plant additions to satisfy regional requirements would be located, in most cases, near the load centers, as this would reduce the cost of transmission. An alternative to this plan would be to locate the thermal power plants along the Colorado River. This would result in reduced conveyance costs for cooling water, but would increase the cost of transmission lines required to deliver the power to load centers. In either alternative, thermal power plants would use cooling towers, and the highly saline water would not be returned to either the stream or to ground water, but would be evaporated in ponds.

It was assumed that no new conventional hydroelectric power plants would be utilized in meeting future power loads. There is a possibility that the controversial Hualapai Project on the Colorado River may be constructed, if future investigations indicate this potential development to be in the public interest.

There is a possibility that imports from the Upper Colorado Region mine-mouth thermal-electric plants could be increased by as much as 10 million kilowatts.

Increased research and development activities may show that exotic power plants could be utilized in meeting future power loads. These exotic power sources would include magnetohydrodynamics, nuclear fusion, fuel cells, thermionics, photovoltaics, and thermoelectrics. The source displaying the most apparent feasibility for central station generation is magnetohydrodynamics or MHD. Plants using nuclear fusion may come into use late in the study period, but much research must be done before such plants can become a reality.

Another alternative source might be geothermal power by importation from the Imperial Valley-Salton Sea area or from hot saline waters in the lower Gila area in Arizona. Much exploration and development work must be done before this source can be considered realistic. Some preliminary information is available on potential geothermal sources in the Salton Sea area, but the possible extension of this geothermal field under the lower Gila area is largely conjectural.

Since electric system facilities would directly affect the atmosphere, water resources and site ecology, sites and designs would be carefully selected to minimize deleterious effects on the esthetic, ecological, and recreational aspects of the environment.

MINERAL RESOURCES

It was assumed that mineral-bearing lands containing both known and unknown ore deposits exist in sufficient quantities in the Lower Colorado Region to support projected mineral production through 2020. Reasonable access to these lands and equitable returns to land owners also have been assumed.

It has been assumed that the mineral industry will continue either to develop its own water supply or to utilize developed local water resources when such developed supplies exist. It has become increasingly evident during the 1960's, especially in the Gila Subregion where ground-water resources are being overdrawn, that the industry soon will be required to seek water supplies elsewhere. Because of the projected increase in mineral industry activity in the Region, purchase of water supplies from developed sources or from future water resource development projects, will become the only alternative means of satisfying water requirements of the mineral industry.

ARCHEOLOGICAL RESOURCES

The Region's unstudied archeological resource is highly important to the understanding of man's use of the area over the past 11,000 years. Because water-related and production-oriented developments will adversely affect the archeological resource, we owe it to future generations to investigate, assess, evaluate, preserve, and salvage this resource prior to its destruction. Provisions must be made on a regionwide basis to scientifically investigate and evaluate this resource as the basis for deciding what should be preserved for future generations, what should be salvaged prior to the start of project activities, and which sites may be allowed to be destroyed.

REGIONAL COMPREHENSIVE FRAMEWORK PROGRAM

CHAPTER F - REGIONAL COMPREHENSIVE FRAMEWORK PROGRAM

GENERAL

The major effort of the functional appendixes and the forepart of this appendix has been to evaluate the elements of the socio-economic environment which are a significant measure of the prosperity, sustainment and gratification of the people living in the area. Studies have been made of the resources available, extent of development, economic activities, and present deficiencies. Projections from this base provided the growth patterns through the 55-year period of study for determining what provisions must be made to maintain or enhance the present qualities of socio-economic environment within the capabilities of the natural resources and at the same time preserving important open space.

The objective of the framework program presented is to serve as a guide for action programs and as a base for continued planning as outlined in Chapter A. The program must be viable and should be periodically updated. It should be recognized that as projections delve farther into the future, a progressively larger element of error can be expected. One only needs to consider what projections made in 1920 might have envisioned for the present. The projections utilized in this study are considered to be in the median range. The public's objectives also change with time as has been particularly in evidence with the recent emphasis on maintaining the quality of the environment rather than solving all problems on the most economical dollar basis. A viable framework program periodically updated and responsive to changing times can assist in achieving balanced development and preservation of resources to meet future needs.

This chapter will present a program for satisfying needs which will provide an orderly sequence of development and investment that will assure continued growth of high quality. Of paramount importance in this framework study of the Lower Colorado Region is the preservation of quality, conservation, and wise choice of use of available water supplies and related land resources. Second in importance is a plan, within the constraints imposed, which will augment the Region's available water supply. Other aspects of the overall plan, while very important, are not as urgent and suitable alternatives are more flexible.

A work group with membership representing the various study interests was organized to formulate the program. The group has selected what appears to be, in its collective and experienced planning judgment, a comprehensive program for the Region.

Framework Planning Concepts

Guidelines

Policies, standards, and procedures that provided the basic rules for formulation of the Lower Colorado Region framework programs are contained in the following documents:

1. Senate Document No. 97 (87th Congress, Second Session, 1962);

2. "Guidelines for Framework Studies" (Water Resources Council, 1967); and

3. "Pacific Southwest Compendium of Framework Planning Policies" (Pacific Southwest Inter-Agency Committee, 1968).

Economic Projections

Projections developed for the Lower Colorado Region were based on projections of population and economic activity provided by OBE-ERS which were modified somewhat to more nearly reflect local historical and anticipated trends. See Chapter L - Alternative Levels of Development for comparisons.

Water Supply

The total annual water requirements in the Lower Colorado River Basin remain nearly constant from 1965 through 2000 as shown on Table F-1. The estimated total average annual water supply based on the runoff period 1906 to 1965 would appear to have been adequate to meet these requirements. However, a maladjustment of supply and demand due to lack of sufficient conveyance and distribution facilities caused mining of about 2.5 million acre-feet of ground water in the Gila Subregion and about 50,000 acre-feet in the Las Vegas area of the Lower Main Stem Subregion in 1965. By year 2000, water requirements as projected in the Upper Colorado Region will deplete the Colorado River supply over 6 million acre-feet annually. At that time, without an augmentation program, the Lower Basin would experience an annual water deficiency of 2.8 million acre-feet increasing to 4.5 million acre-feet by 2020. By 2020 the vegetative management program would provide an increase in water yield of 180,000 acre-feet annually for beneficial use in the Region. The remaining deficiency must then be met either through increasing ground-water overdraft, satisfied by importation of water from another source, remain unmet, or be resolved by some combination of these alternatives.

It should be noted that the future water supply deficiencies as shown on Table F-1 would be greatly increased if the runoff period selected did not prove to be representative. The 1931 to 1965 Colorado

Table F-1
Lower Colorado Region
Water Supply Augmentation

Unit: Million Acre-Feet

	1965	1980	2000	2020
Water Supply				
Colorado River (1906-65) 1/				
Modified Flow, Compact Point	11.64	10.26	8.97	8.54
Estimated System Spill 2/	- 0.65	- 0.52	- 0.15	- 0.15
Main Stem Reservoir and Channel Losses 3/	- 1.86	- 1.59	- 1.59	- 1.59
Available Natural Supply	9.13	8.15	7.23	6.80
National Importation Obligation (Mexican Treaty including associated losses) 4/	--	--	1.80	1.80
Total Available Colorado River Water Supply Lower Colorado River Basin	9.13	8.15	9.03	8.60
Out of Region Depletions	- 6.50	- 5.90	- 5.90	- 5.90
California	(5.00)	(4.40)	(4.40)	(4.40)
Mexican Treaty	(1.50)	(1.50)	(1.50)	(1.50)
Colorado River Water Available to Lower Colorado Region	2.63	2.25	3.13	2.70
Local Water Supply	3.12	3.12	3.12	3.12
(Lower Main Stem)	(0.90)	(0.90)	(0.90)	(0.90)
(Little Colorado)	(0.42)	(0.42)	(0.42)	(0.42)
(Gila)	(1.80)	(1.80)	(1.80)	(1.80)
Total Available Water Supply Lower Colorado Region	5.75	5.37	6.25	5.82
Lower Colorado Depletion Requirements	5.83	6.88	7.26	8.52
Beneficial Uses	(5.23)	(6.24)	(6.80)	(7.94)
Losses Associated with Reuse and Recycling 5/	(0.60)	(0.64)	(0.46)	(0.58)
Regional Water Deficiency	0.08	1.51	1.01	2.70

Table F-1 (Continued)
Lower Colorado Region
Water Supply Augmentation

Unit: Million Acre-Feet

	1965	1980	2000	2020
Regional Augmentation Program	--	0.03	0.57	2.53
Improved Watershed Yield 6/	--	(0.03)	(0.12)	(0.18)
Importation	--	--	(0.45)	(2.35)
National Importation Program	--	--	1.80	1.80
Remaining Regional Water Deficiency (continued ground-water overdraft)	0.08	1.48	0.44	0.17

1/ Except where noted, this information is from Appendix V, Water Resources, Comprehensive Framework Studies, Lower Colorado Region (Second Review Draft, June 1970).

2/ From Lower Colorado River Basin Operation Studies--90th Congress, Second Session, House of Representatives, Serial No. 90-5, Hearings on H. R. 3300, Colorado River Basin Project, Part II, U.S. Government Printing Office, Washington, D.C., 1968.

3/ These losses reflect reductions for the annual effects of the phreatophyte control and river channelization programs assumed to be accomplished by 1980, in the amounts of 100,000 acre-feet and 170,000 acre-feet, respectively.

4/ 90th Congress, Public Law 90-537, An Act to Authorize . . . the Colorado River Basin Project. . . , September 1968 to relieve both the Upper and Lower Colorado River Basins of their commitment to equally share the burden of delivering 1.5 million acre-feet to Mexico.

5/ Includes estimates of water losses associated with the recycling of return flows through the ground-water reservoir including in-transit losses and losses associated with the treatment and direct reuse of water. The resultant regional average recycling efficiency ranges between 84 and 88 percent.

6/ Increased runoff from selected areas as the result of vegetative management practices.

River runoff produced an average annual water supply of 2 million acre-feet less than the longer period.

Multipurpose Planning

Recognizing the most practical and efficient method for meeting the large and numerous demands for water and related land resources, and for maintaining environmental quality in developing the natural resources, a framework program has been developed which is multipurpose oriented. The demands stated in the functional appendixes are single-purpose oriented. However, the multipurpose framework program attempts to meet as much of the individual functional demands as practicable. Some of the demands that are not met by the multipurpose program, either because of insufficiency of the resource or because of location, are treated as single-purpose items in the framework program.

In keeping with the guidelines set out for this study, the present and projected requirements for services, products, environmental development, and resources were all given due consideration.

The volume of import water required was calculated to satisfy all needs, with no consideration of priorities nor discounting of stated needs.

Early Action Program, 1966 - 1980

The early action program objectives are to fully utilize all surface water supplies available to the Region, seek every means of conserving water for beneficial use, to explore the effects of ground-water overdraft, and investigate possibilities of untapped ground-water reserves that might be utilized as an interim measure until augmentation from sources outside the Region could be achieved.

Multipurpose Water Supply

Several water supply projects, now authorized, are included in the 1965 to 1980 framework program. These projects, when constructed, will provide facilities to convey 1.67 million acre-feet of the Region's share of the Colorado River to central Arizona for multipurpose uses; provide water to New Mexico by exchange; provide facilities to convey 0.13 million acre-feet to Las Vegas, Nevada, for municipal and industrial water supply; provide municipal, industrial and supplemental and new irrigation water for the Dixie Project in southern Utah; provide 3.7 million acre-feet of multipurpose reservoir storage facilities within the Region; and the recovery of approximately 270,000 acre-feet of water along the Colorado River. In addition, 35,000 acre-feet of water will be recovered in the Gila Subregion. Tertiary treatment facilities would make available 260,000 acre-feet for direct reuse.

REGIONAL PROGRAM
1966-1980

The 1966 to 1980 land treatment program provides water yield improvement measures on about 175,000 acres of coniferous, chaparral, and commercial timber lands to increase yield by 30,000 acre-feet. Means to conserve and more efficiently utilize existing water supplies are also included in the early action program and are discussed under the appropriate functions.

After implementation of the early action program, there remains a water supply deficiency of about 1.4 million acre-feet after 1980 in the central Arizona portion of the Gila Subregion. See Map 13 following for potential water resource facilities.

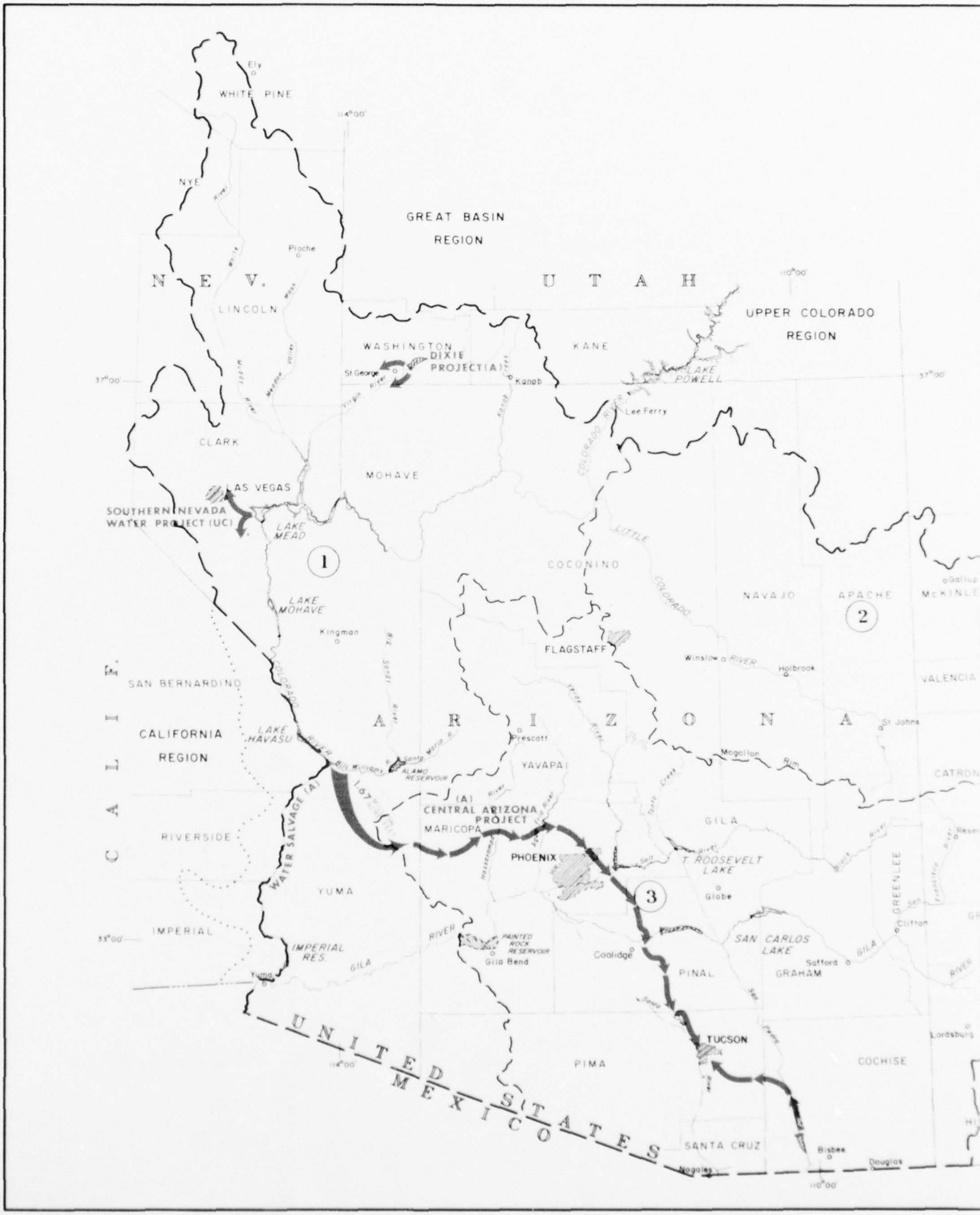
Water Quality

Until augmentation and/or salinity control measures are installed, the increased use of water in both the Upper and Lower Colorado Regions will result in further quality degradation. Unless remedial measures are taken this will have very serious consequences, especially to agricultural production downstream from Parker Dam where the salt concentrations are presently at a critical level for some crops. A proposed basinwide salinity improvement program would provide measures to reduce the possible increases. That portion of the basinwide salinity program included in the Lower Region provides for the treatment of a saline springs area contributing salts to the Colorado River and a tertiary treatment plant for treating municipal and industrial waste flows in the Las Vegas area. Treatment facilities and provisions for reuse are also provided for municipal and industrial waste water occurring in the other urban centers of the Region.

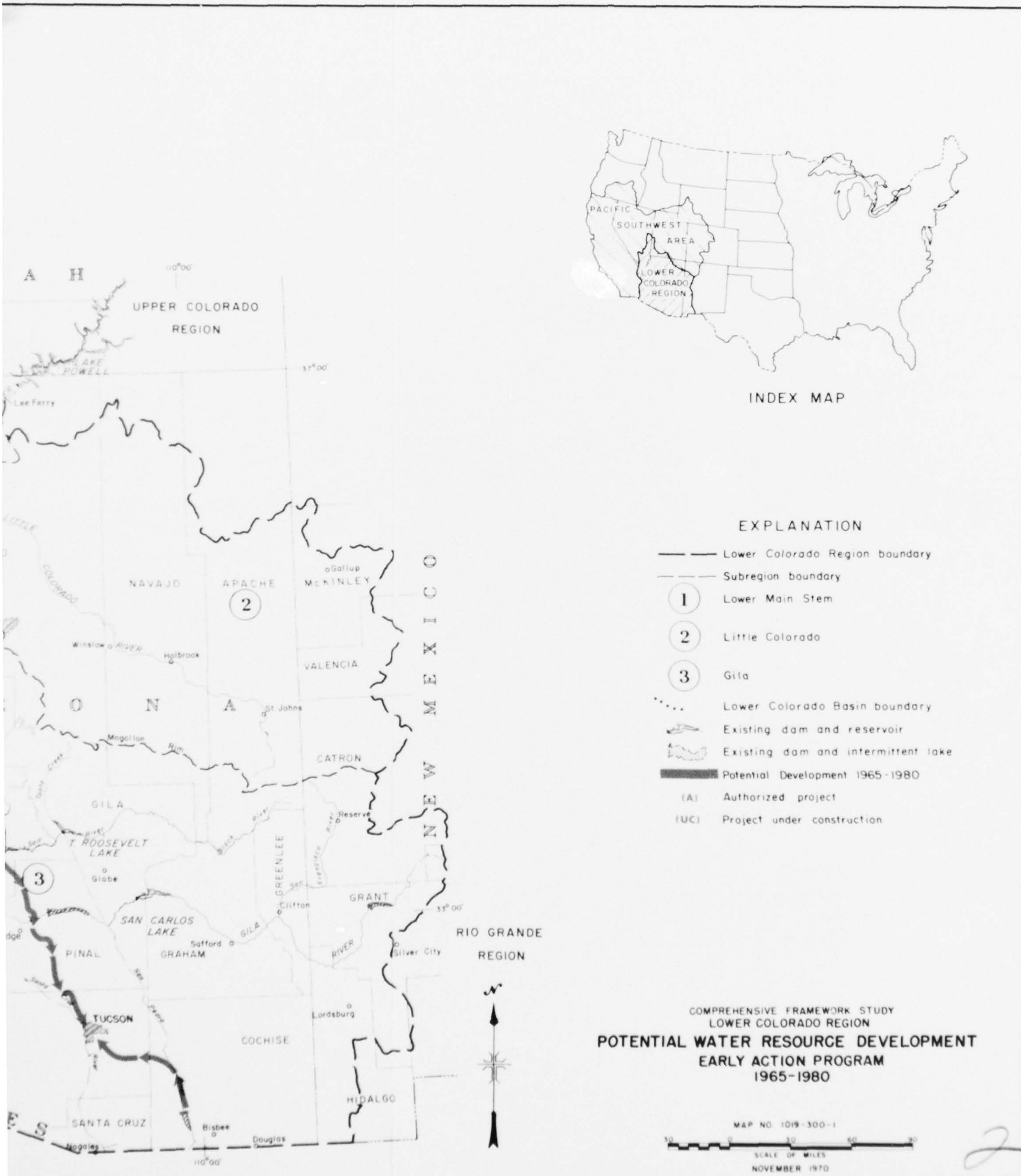
Land Treatment and Management

The land treatment and management program is needed to minimize irreversible losses of the land resources and preserve the freedom of choice for future resource users. The program includes treatment of 19.3 million acres by 1980 at a total cost of about $205.7 million. Ideally, the land treatment and management program should harmonize with all water and related land resource development programs required to satisfy present and projected demands within the Region.

Cropland--Measures such as diversions, levees and dikes, channel improvement, floodways, and streambank protection were considered for erosion, sediment, and runoff control on cropland. These measures are primarily for protection of the land and improvements, but also help maintain and/or improve the productivity of the land, reduce the sedimentation and erosion hazards that would adversely affect the operation and maintenance of structural measures, and help in keeping soil losses within allowable limits. These measures have a beneficial effect on environmental quality objectives. Water pollutants such as sediment, plant nutrients, and pesticides which could be carried to the watercourses by floodwaters are retained on the land where they are needed.



GREAT BASIN REGION
UPPER COLORADO REGION
CALIFORNIA REGION
N E V.
U T A H
A R I Z O N A
C A L I F.
UNITED STATES
MEXICO
WHITE PINE
NYE
LINCOLN
CLARK
WASHINGTON
KANE
MOHAVE
COCONINO
NAVAJO
APACHE
MCKINLEY
VALENCIA
CATRON
YAVAPAI
GILA
MARICOPA
YUMA
PINAL
GRAHAM
GREENLEE
PIMA
SANTA CRUZ
COCHISE
SAN BERNARDINO
RIVERSIDE
IMPERIAL
Ely
Pioche
St George
Kanab
Lee Ferry
LAS VEGAS
Kingman
FLAGSTAFF
Winslow
Holbrook
St Johns
Gallup
Prescott
PHOENIX
Globe
Coolidge
Gila Bend
Safford
Clifton
Yuma
TUCSON
Lordsburg
Bisbee
Douglas
Nogales
DIXIE PROJECT (A)
SOUTHERN NEVADA WATER PROJECT (UC)
(A) CENTRAL ARIZONA PROJECT
WATER SALVAGE (A)
LAKE MEAD
LAKE MOHAVE
LAKE HAVASU
LAKE POWELL
ALAMO RESERVOIR
PAINTED ROCK RESERVOIR
IMPERIAL RES.
T ROOSEVELT LAKE
SAN CARLOS LAKE
COLORADO RIVER
LITTLE COLORADO RIVER
GILA RIVER
Mogollon Rim
1
2
3
37°00'
33°00'
114°00'
110°00'


INDEX MAP
PACIFIC SOUTHWEST AREA
LOWER COLORADO REGION
EXPLANATION
Lower Colorado Region boundary
Subregion boundary
1 Lower Main Stem
2 Little Colorado
3 Gila
Lower Colorado Basin boundary
Existing dam and reservoir
Existing dam and intermittent lake
Potential Development 1965-1980
(A) Authorized project
(UC) Project under construction
UPPER COLORADO REGION
RIO GRANDE REGION
NEW MEXICO
LAKE POWELL
Lee Ferry
NAVAJO
APACHE
McKINLEY
Gallup
VALENCIA
CATRON
Winslow
Holbrook
St Johns
Mogollon Rim
GILA
T ROOSEVELT LAKE
Globe
Reserve
GREENLEE
GRANT
Clifton
SAN CARLOS LAKE
Safford
GRAHAM
PINAL
Silver City
TUCSON
Lordsburg
COCHISE
HIDALGO
SANTA CRUZ
Bisbee
Douglas
Nogales
110°00'
37°00'
33°00'
COMPREHENSIVE FRAMEWORK STUDY
LOWER COLORADO REGION
POTENTIAL WATER RESOURCE DEVELOPMENT
EARLY ACTION PROGRAM
1965-1980
MAP NO. 1019-300-1
SCALE OF MILES
NOVEMBER 1970

Soil surveys are necessary for implementation of the irrigation water management, and erosion, sediment, and runoff control measures.

Installation of the program is recommended for about 153,000 acres between 1966 and 1980 at a total cost of $3.5 million. Of this acreage 76 percent is in the Gila Subregion, 22 percent in the Lower Main Stem Subregion, and 2 percent is in the Little Colorado Subregion.

Rangeland--The program for rangeland was formulated by purposes. These were: erosion, sediment, and runoff control; forage production improvement; wildfire prevention and suppression; and associated programs. Measures considered in developing an effective land treatment and management program on rangeland consist of (1) small structural measures such as grade stabilization structures, diversions, and terraces, (2) vegetative measures such as grass, tree or shrub plants, and (3) intensive management, the orderly and efficient use of water, land, and other resources is necessary for successful multiple use production while protecting and improving environmental values. The program was designed to reduce sediment yield, reduce wildfire damage, improve water quality and/or quantity, and increase the productive ability of the land.

A total of 15.3 million acres is recommended for treatment at a total cost of $80.9 million between 1966 and 1980. Subregional distribution of the acreage would be about 45 percent in the Lower Main Stem Subregion, and 21 and 34 percent in the Little Colorado and Gila Subregions, respectively.

Forest Land--Programs for development and management of forest land and resources are designed to utilize and maintain or improve the total productive capacity of the land and water, including wood, forage, recreation, wildlife, and water to meet the regional and national needs of the people. These programs include thinning, reforestation, insect and disease control for increasing wood production; conversion of woodland and chaparral for increasing forage; management of vegetation, resources, and activities for the enhancement of the recreation resources, including esthetic and environmental values; management of vegetation for improved water quality; and vegetative management for increasing water yield. See water yield augmentation map following.

Structural and other management and development programs are designed to reduce sheet, gully, and streambank erosion, control peak runoff, and prevent downstream floods. Roads, trails, and other improvements are designed, constructed, and maintained to minimize erosion and sediment yield and deposition.

About 3.6 million acres of forest land in the Region are included for treatment at an estimated cost of $115.8 million between 1966 and 1980. Approximately 19 percent of the lands to receive treatment are in

the Lower Main Stem Subregion, and 26 and 55 percent are in the Little Colorado and Gila Subregions, respectively.

Urban and Other--Measures such as diversions, levees and dikes, channel improvement, floodways and vegetative were considered for erosion, floodwater, and sediment control in urban and mined areas, and along roadsides, utility rights-of-way, etc. These measures may be temporary or permanent. The protective vegetative cover of land being developed is usually disturbed by land forming or heavy equipment. These areas should be provided temporary protection during and immediately after construction. Permanent type measures must be planned and installed during the initial stages of any development to adequately protect the area from future erosion, floodwater, and sediment damages.

It is recommended that a total of 182,000 acres of urban and other lands receive treatment between 1966 and 1980 at a total cost of $5.5 million. About 59 percent of the treatment would occur in the Gila Subregion, 31 percent in the Lower Main Stem Subregion, and about 10 percent in the Little Colorado Subregion.

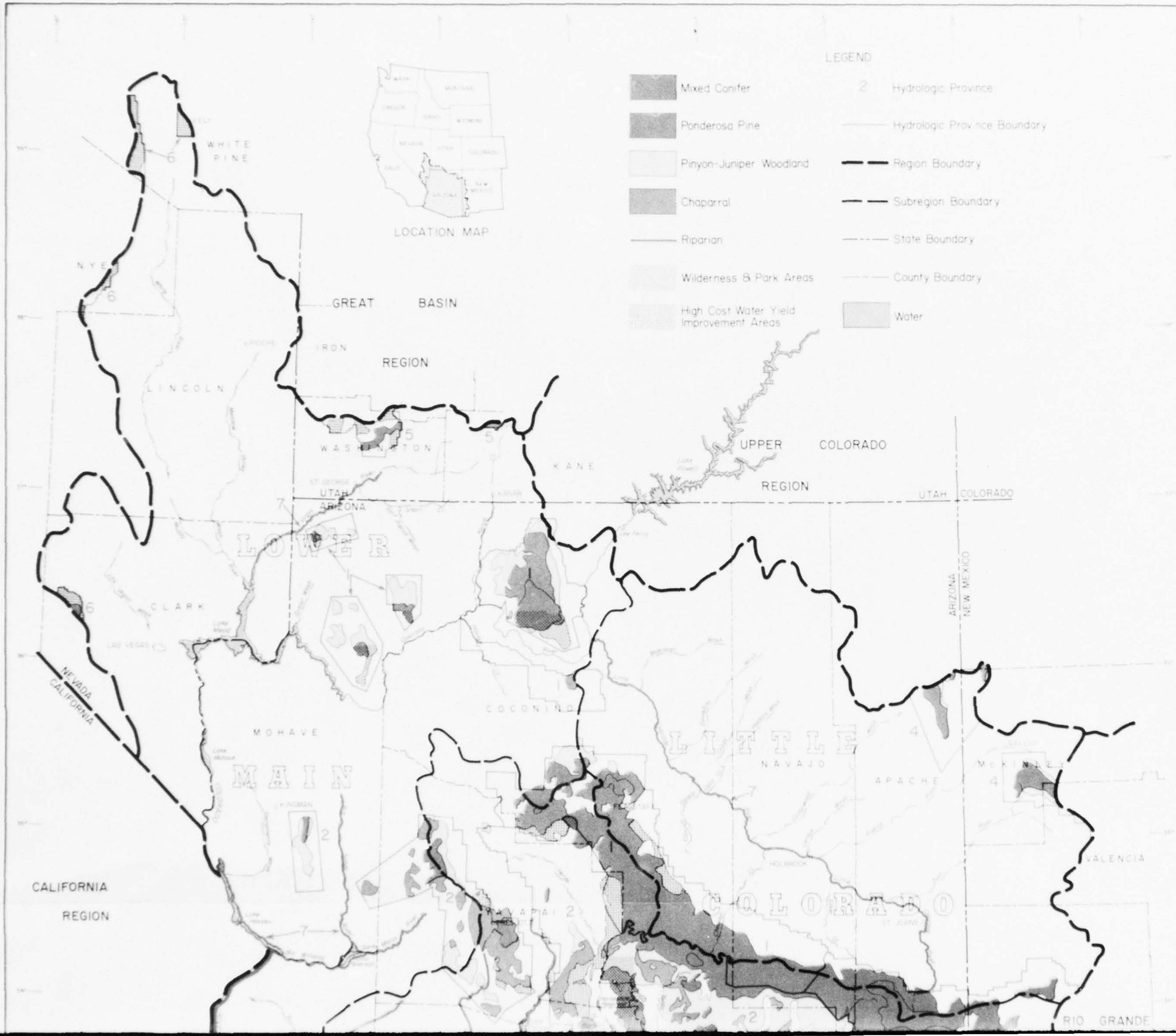
Flood Control

The flood damage reduction program involves the consideration of the control of water and the controlled use of the flood plain. Measures used to control the flow of water include reservoirs, retarding structures, levees, and channel improvements. Measures considered to control the flood plain use include flood forecasting, evacuation, and flood plain regulations involving zoning ordinances, building codes, open space requirement, development policies, subdivision regulations, tax adjustments, and warning signs.

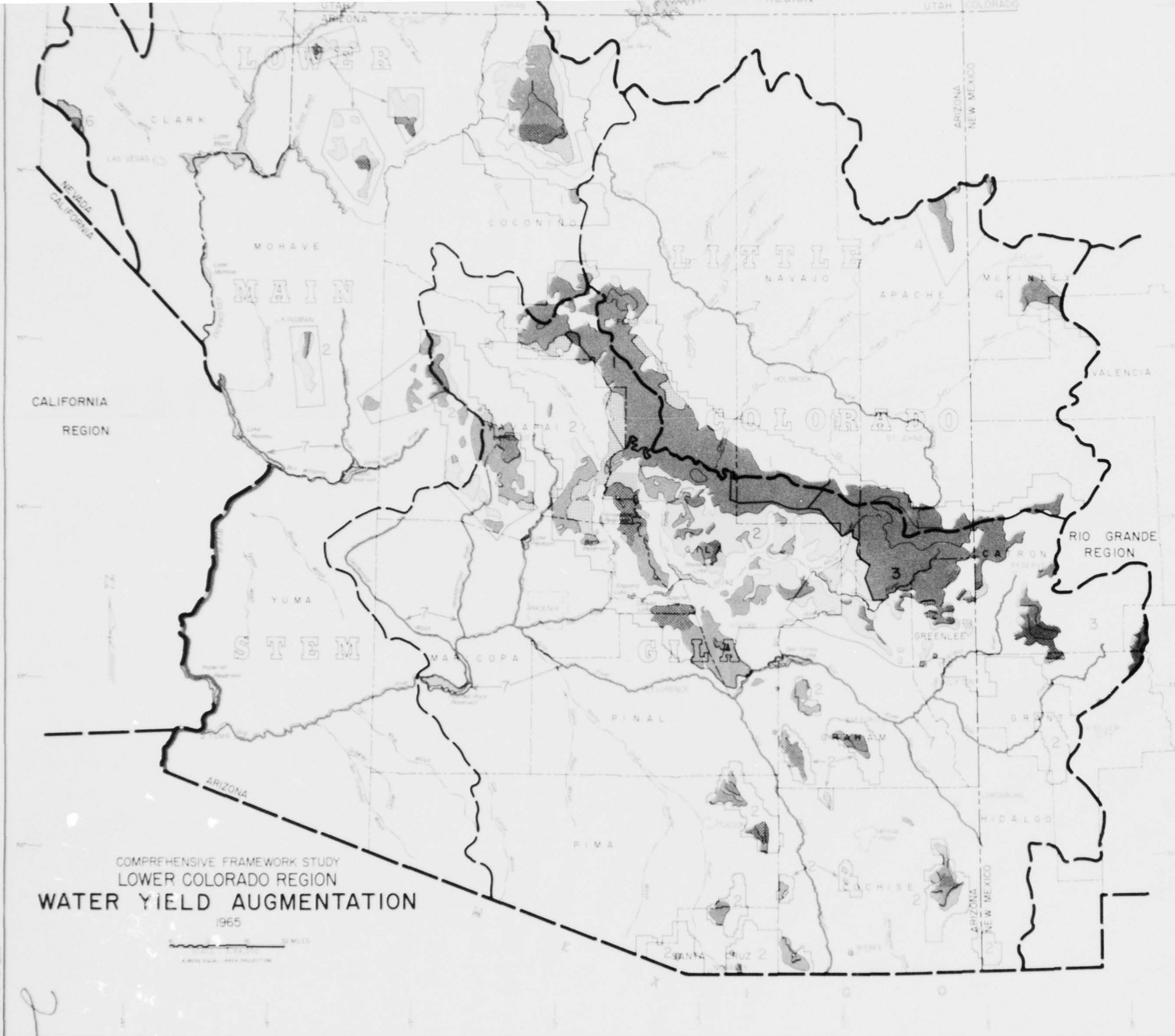
Included in the early action program is 3.1 million acre-feet of floodwater storage. About 2.5 million acre-feet of this new storage are in downstream reservoirs and 0.6 million acre-feet are in upstream reservoirs and retarding structures. Multipurpose reservoirs provide 2.1 million acre-feet of the downstream floodwater storage.

Local protection projects consisting of channel improvement or levees are provided in the programs where floodwater storage would not fully satisfy the flood protection needs. The plan includes 208 miles of levees and 241 miles of channel improvements in the downstream area and 65 miles of levees and 345 miles of channel improvements in the upstream area. See flood control program map following.

In formulation of the flood control program, consideration was given to land treatment and management practices that reduce damaging peak runoff. These practices have an effect in reducing peak runoff from the smaller, less intensive storms but have less effect on major

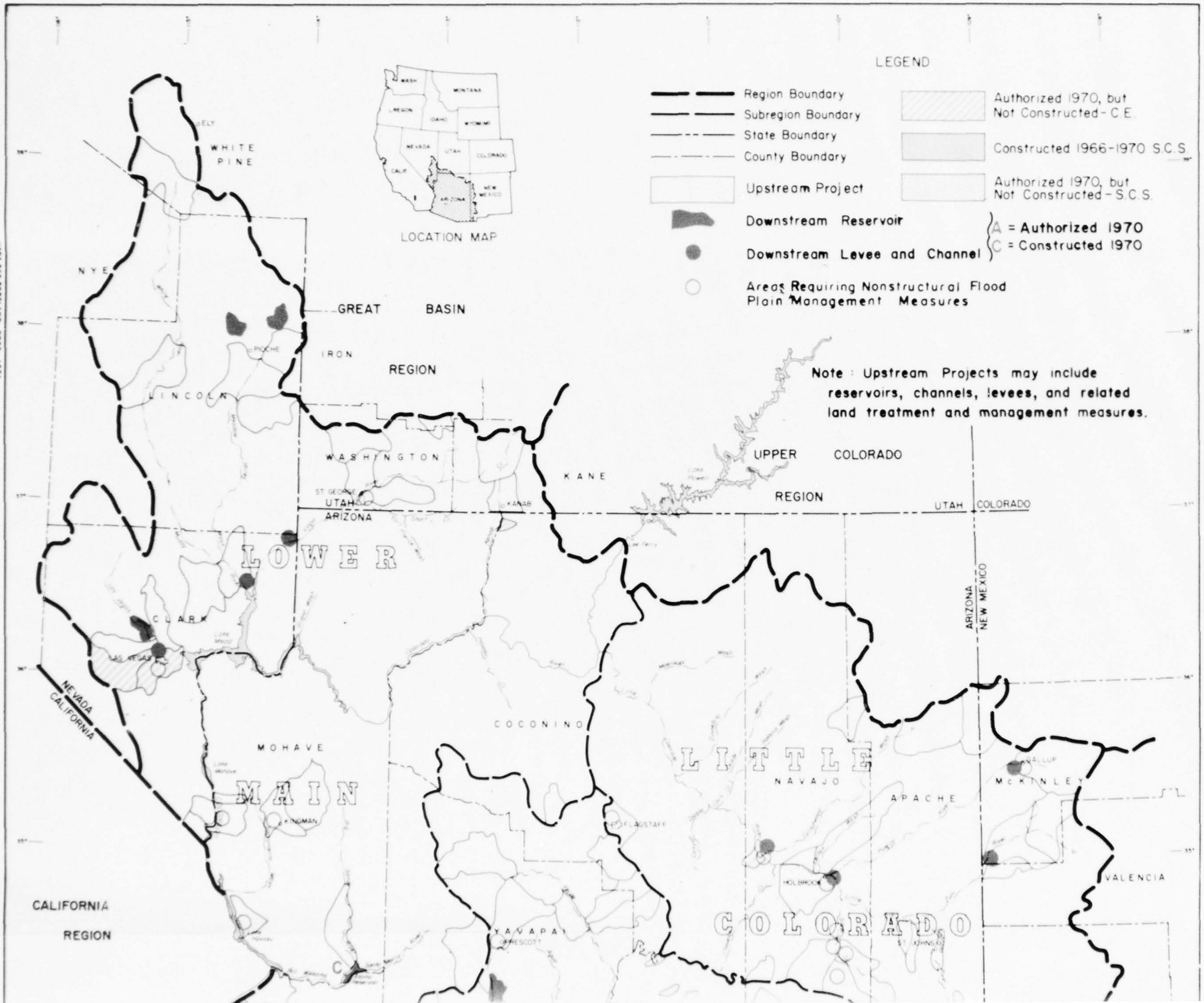


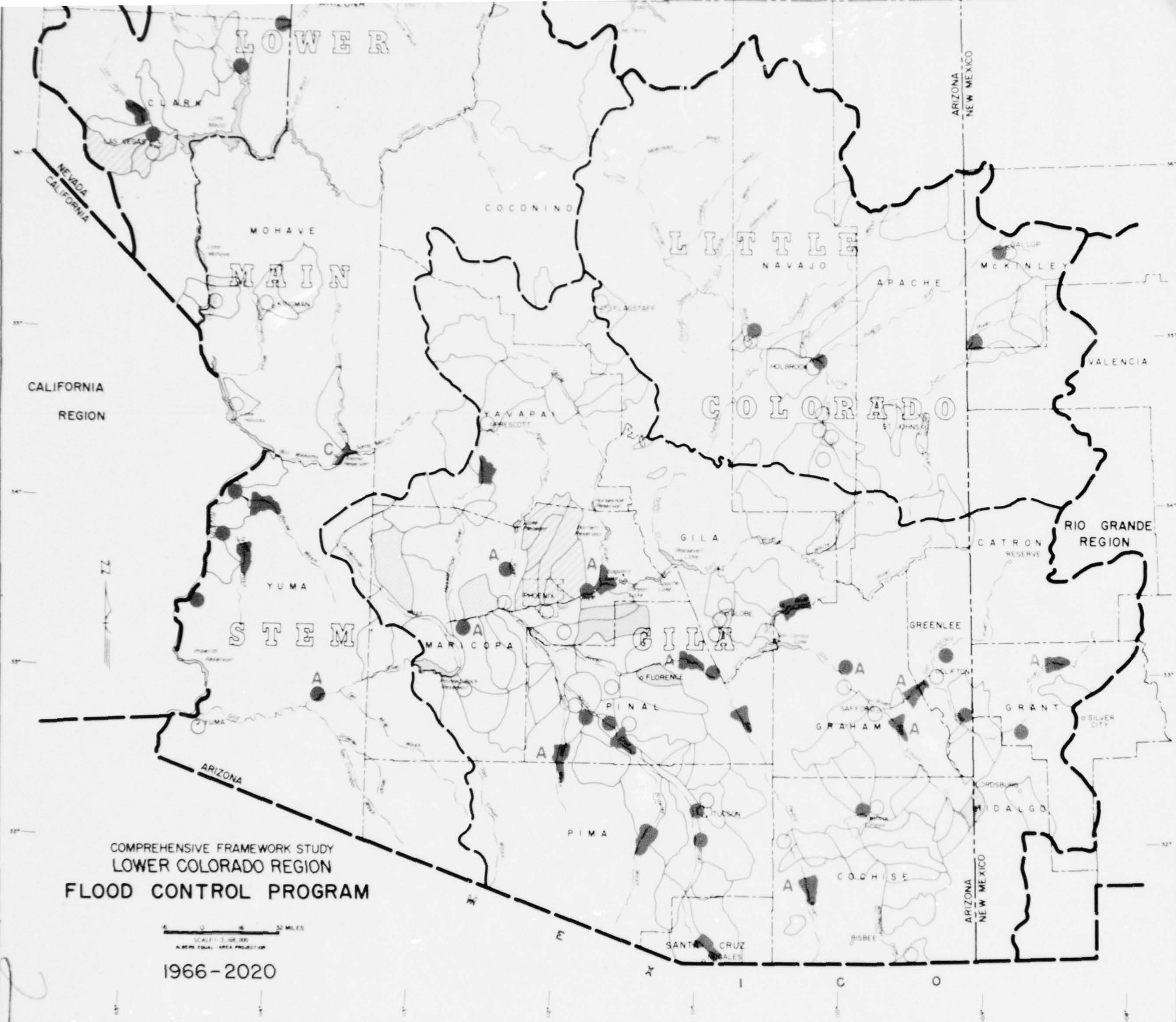
LEGEND
Mixed Conifer
Ponderosa Pine
Pinyon-Juniper Woodland
Chaparral
Riparian
Wilderness & Park Areas
High Cost Water Yield Improvement Areas
2 Hydrologic Province
Hydrologic Province Boundary
Region Boundary
Subregion Boundary
State Boundary
County Boundary
Water
LOCATION MAP
GREAT BASIN REGION
UPPER COLORADO REGION
LOWER
MAIN
COLORADO
LITTLE
CALIFORNIA REGION
RIO GRANDE
NEVADA
CALIFORNIA
UTAH
ARIZONA
COLORADO
NEW MEXICO
WHITE PINE
NYE
LINCOLN
CLARK
IRON
WASHINGTON
KANE
MOHAVE
COCONINO
NAVAJO
APACHE
McKINLEY
VALENCIA



COMPREHENSIVE FRAMEWORK STUDY
LOWER COLORADO REGION
WATER YIELD AUGMENTATION
1965
CALIFORNIA REGION
RIO GRANDE REGION
NEVADA
CALIFORNIA
ARIZONA
NEW MEXICO
UTAH
COLORADO
LOWER
MAIN
STEM
LITTLE
COLORADO
GILA
CLARK
MOHAVE
COCONINO
NAVAJO
APACHE
McKINLEY
VALENCIA
YUMA
MARICOPA
PINAL
PIMA
GRAHAM
GREENLEE
CATRON
GRANT
HIDALGO
COCHISE
SANTA CRUZ

M7-S-21431H-N


LEGEND
Region Boundary
Subregion Boundary
State Boundary
County Boundary
Upstream Project
Downstream Reservoir
Downstream Levee and Channel
Areas Requiring Nonstructural Flood Plain Management Measures
Authorized 1970, but Not Constructed - C.E.
Constructed 1966-1970 S.C.S.
Authorized 1970, but Not Constructed - S.C.S.
A = Authorized 1970
C = Constructed 1970
LOCATION MAP
Note : Upstream Projects may include reservoirs, channels, levees, and related land treatment and management measures.
GREAT BASIN REGION
UPPER COLORADO REGION
CALIFORNIA REGION
LOWER
MAIN
LITTLE
COLORADO
WHITE PINE
NYE
LINCOLN
IRON
WASHINGTON
KANE
CLARK
MOHAVE
COCONINO
NAVAJO
APACHE
McKINLEY
VALENCIA
YAVAPAI
UTAH
ARIZONA
COLORADO
NEW MEXICO
NEVADA
CALIFORNIA
ST. GEORGE
KANAB
PIOCHE
LAS VEGAS
KINGMAN
FLAGSTAFF
HOLBROOK
GALLUP
PRESCOTT
ST. JOHNS
USDA SCS PORTLAND, OREG. 1971



COMPREHENSIVE FRAMEWORK STUDY
LOWER COLORADO REGION
FLOOD CONTROL PROGRAM

SCALE 1:3,168,000
ALBERS EQUAL AREA PROJECTION
16 0 16 32 MILES

1966-2020

M7-N-21431J

2

storms. Those land treatment measures and management practices which provide at least 10-year flood protection for agricultural areas and for resources and developments on forest land and rangeland are included in the flood control program. The program includes treatment of 188,000 equivalent acres.

The early action program provides for continued preparation of flood plain information reports requested by local authorities on a priority basis. The program includes making maximum use of nonstructural measures in flood plain management as a means of preventing damage from floodwater. This program would include flood forecasting, zoning, building codes, health regulations, flood proofing, and purchase of private lands subject to flooding for open space use.

The program would reduce upstream damages by about $22 million and downstream damages by about $10 million annually. The estimated remaining upstream damages would be about $31 million annually and remaining downstream damages would be nearly $10 million annually. The total cost of the program is estimated at $359 million.

Irrigation and Drainage

The early action irrigation program includes increased conservation of existing water supplies, more efficient utilization of land developed for irrigation, and about 200,000 acres of new irrigation development of which about 110,000 acres are expected on Indian lands. About 28,000 acres of this new irrigation development will compensate urban displacement.

The program includes completion by 1980 of the ongoing rehabilitation of irrigation water conveyance systems to facilitate more efficient utilization and the conservation of water supplies. Onfarm water management measures such as land leveling and water control structures are recommended for about 573,000 acres between 1966 and 1980 at a total cost of $56.3 million. These measures are for better control and more efficient use of irrigation water and/or to reduce costs of irrigation. Authorized Central Arizona Project and Dixie Project facilities will provide supplemental water for lands presently developed for irrigation, some additional irrigation in Utah, and regulatory storage to facilitate more efficient utilization of water supplies. The Central Arizona Project provides that each contract for the delivery of project water will require that the canals and distribution systems through which water is conveyed be maintained with linings adequate to prevent excessive conveyance losses.

During the period 1966 to 1980, the irrigated acreage is expected to increase from 1.32 million to 1.49 million acres. A portion of the increase would result from declines in crop failures and idle lands, largely because of the Central Arizona Project. A minor amount of

additional irrigation is expected in outlying ground-water basins. Though the irrigated acreages would increase by 173,000 acres, the increased water utilization efficiencies will result in an increased water withdrawal requirement of only 340,000 acre-feet. Additional drainage facilities are provided to serve 68,000 acres largely in the Lower Main Stem Subregion.

Municipal and Industrial Water

Projects presently under construction or authorized for construction constitute most of the municipal and industrial water supply early action program providing 446,000 acre-feet of water by 1980. These projects will provide water for municipal and industrial uses to the major population centers of Las Vegas, Nevada, and Phoenix and Tucson, Arizona; and the less populated area of Washington County, Utah. Two of the projects are multipurpose in scope and one, the Las Vegas facility, meets only municipal and industrial needs.

Desalting facilities to treat brackish water for 8 municipalities would have a total capacity of 18 million gallons per day. Other communities are expected to meet most of their water needs through 1980 by continued development of ground-water resources. The program includes costs for the development of community water supplies.

Recreation

The single-purpose recreation program is essentially one of land acquisition, recreation development, and operation, maintenance and replacement of facilities. By the year 1980, about $194 million for development and acquisition will be required to meet total recreation needs of 51 million recreation days. Water-based recreation needs will total 43 million recreation days by 1980 and would cost over $173 million for development and acquisition.

Implementation of the program to meet these needs will require judicious planning, coordination, and funding. Within existing legal institutional, physical, and financial constraints, only 35 percent of the needs can be met. Not only will the non-Federal entities have to expand their efforts by two or three times, but Federal involvement, both direct and indirect, will have to be expanded. Urban-oriented recreation developments will particularly need Federal attention since they account for over 65 percent of the total recreation costs.

Water-based recreation needs can be partially met by facility development at existing lakes and reservoirs in the areas of need. Water needs in the Little Colorado Subregion will be unmet. Presently authorized water project construction would provide 32,700 acres of alternative recreation opportunity as it is needed. Other means of meeting water-based recreation needs include canal-side park, projects using reclaimed water, and single-purpose recreation impoundments.

The states included in the Lower Colorado Region have completed comprehensive state recreation plans. These plans should be kept current and flexible to meet the increasing and changing public desires.

Fish and Wildlife

The additional 32,700 acres of water surface that will be provided by presently authorized projects will assist in meeting fishing demand in conjunction with recreation uses.

The multipurpose developments expected to be constructed by 1980, including the Alamo, Dixie, and Central Arizona Projects, have the projected potential to provide about 1.2 million man-days of fishing annually. Continued development of the Colorado River and the construction and improvement of fishery developments by state, Indian, and private interests will provide about 2.0 million man-days of fishing annually. Two cold water fish hatcheries are being constructed and will be in production by 1980. Projected needs indicate that three additional hatcheries should be provided before 1980.

Fishing demand not met by multipurpose reservoirs would be met by primary-purpose fishing lakes of 200 acres or less serving primarily the population centers of Las Vegas, Gallup, Phoenix, and Tucson-Douglas. Approximately one-fourth of the fish habitat would be within the city proper and the remaining three-fourths within 75 miles of the cities.

The program provides for 1,960 acres of primary-purpose fish habitat in the 1966 to 1980 period. Associated fishermen access facilities are provided to assure optimum fishing use of the total habitat expected to be in existence in 1980. The program also provides the equivalent of one cold water and two warm water hatcheries by 1980 to stock the available habitat.

To assure the development and protection of high quality fishing areas and preservation of the natural environment, approximately 10 percent of the surface acres required to satisfy the fishery demands necessarily must have restrictions on the amount of public use. Planning and development of these areas should begin prior to 1980.

Fishery management practices will be continued to maintain a ratio between game and nongame fish that yields the most productive sport fishery.

The primary concern in an attempt to meet future wildlife needs is to preserve or improve the existing wildlife habitat. Approximately 330,000 acres of existing high value riparian and wetland habitat would be set aside between 1966 and 1980 to be administered primarily for wildlife management. This program would assure the perpetuation of

much habitat which is highly productive of small game, big game, and nongame species. The wetlands are important to migrating waterfowl. The management of the selected areas would be directed to the maximum production of fish and wildlife, with appropriate consideration of compatible and/or complementary uses.

The early action program, 1966 to 1980, includes the construction of access roads into inaccessible areas and the development of approximately 1,000 wildlife water facilities. These facilities are intended to be constructed in water-short areas of multipurpose as well as primary-purpose public lands. See map following page 204.

Electric Power

It is anticipated that during the 1966 to 1980 period, the principal source of additional electric power would be imports from mine-mouth plants in the Upper Colorado Region which will supply about 4.3 gigawatts of generating capacity. Electric power generating capacity to be developed within the Region is estimated as 0.8 gigawatts from the Montezuma pumped storage plant near Phoenix and 1.9 gigawatts from fossil-fueled thermal power plants. For principal transmission lines, see map following page 204.

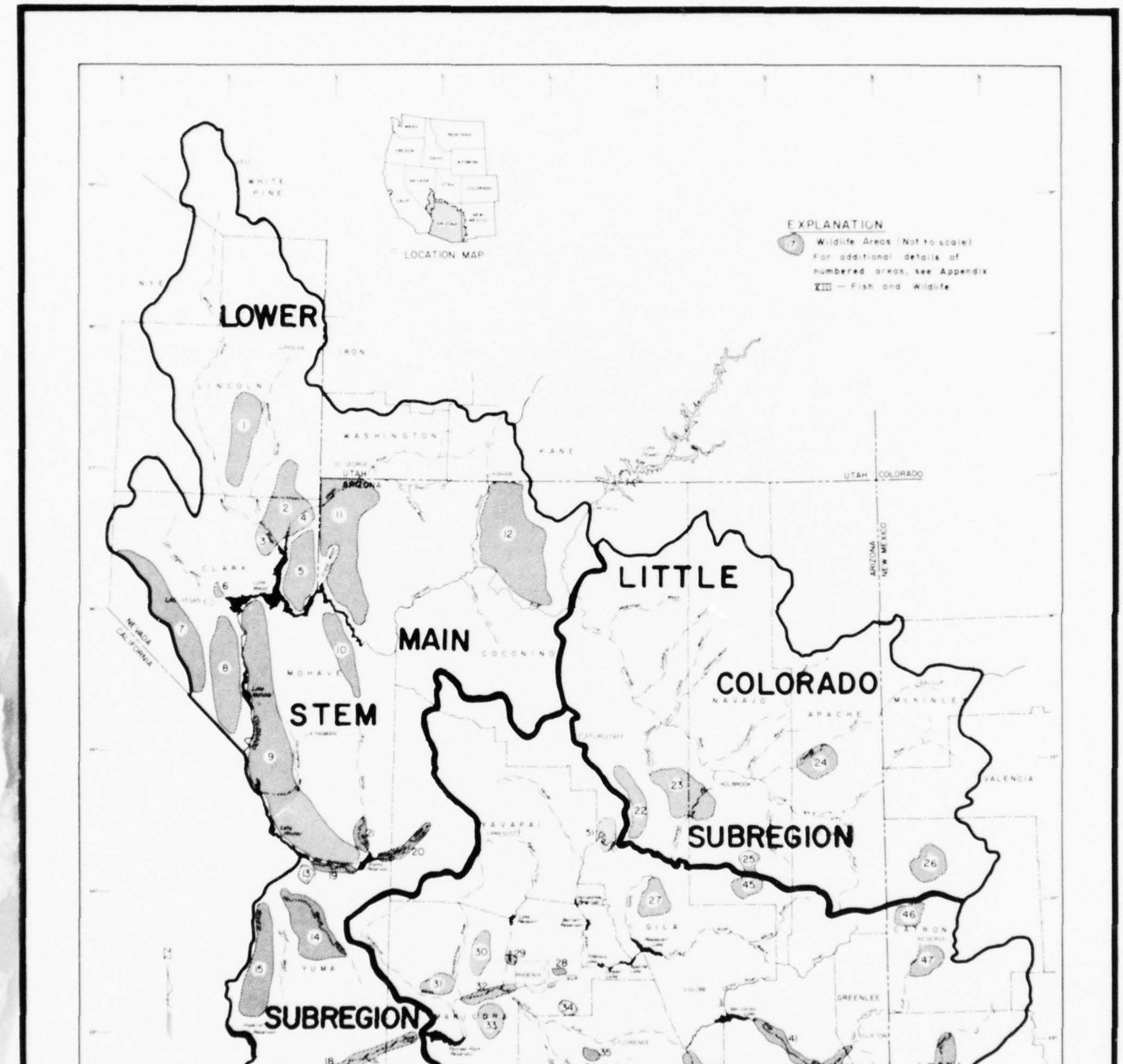
Continuing Program, 1981 - 2020

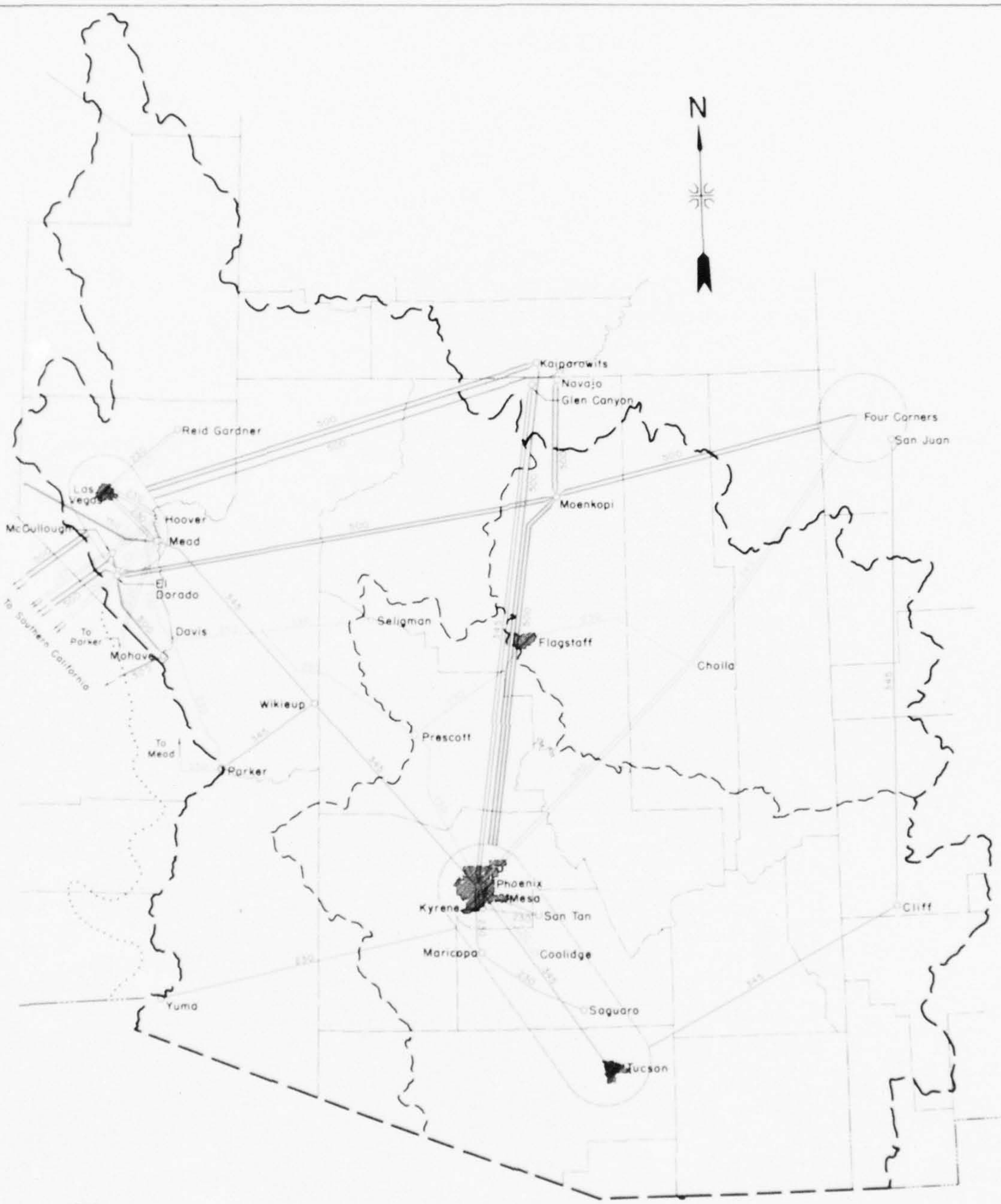
Multipurpose Water Supply

By 1980, all feasible water conservation and utilization measures will have been implemented in the Region. In 1980, the water supply deficiency will be an estimated 1.5 million acre-feet, which can be met only by continued ground-water overdraft. Water withdrawal requirements are projected to increase from the 1980 level of 11.0 million acre-feet to a level of 13.0 million acre-feet in 2020. Depletions will increase from 6.9 to 8.5 million acre-feet in the same period.

The continuing water supply program will provide water to satisfy the increasing demands and to greatly reduce the ground-water overdraft. The only foreseeable method to effectively augment the regional water supply will be by importation from outside the Region. Importation studies should include consideration of the needs of the entire Pacific Southwest Area for reasons of efficiency and potential savings in cost.

The first augmentation consideration will be as stated in Title II of the Colorado River Basin Project Act: "The Congress declares that the satisfaction of the requirements of the Mexican Water Treaty from the Colorado River constitutes a national obligation which shall be the first obligation of any water augmentation project planned pursuant to Section 201 of this Act and authorized by the Congress."


EXPLANATION
Wildlife Areas (Not to scale)
For additional details of numbered areas, see Appendix XIII — Fish and Wildlife
LOCATION MAP
LOWER
MAIN
STEM
SUBREGION
LITTLE
COLORADO
SUBREGION
GILA
SUBREGION
WHITE PINE
NYE
LINCOLN
IRON
WASHINGTON
KANE
CLARK
MOHAVE
COCONINO
NAVAJO
APACHE
MCKINLEY
VALENCIA
YAVAPAI
GILA
YUMA
MARICOPA
PINAL
GRAHAM
GREENLEE
CATRON
GRANT
HIDALGO
PIMA
COCHISE
SANTA CRUZ
UTAH
ARIZONA
COLORADO
NEW MEXICO
NEVADA
CALIFORNIA
M E X I C O
COMPREHENSIVE FRAMEWORK STUDY
LOWER COLORADO REGION
DESIGNATED
WILDLIFE AREAS



Notes

1. No attempt has been made to forecast either additions or deletions of transmission facilities of less than 230 KV

2. Transmission lines simplified in congested areas

LEGEND

TRANSMISSION LINES — PROJECTED AS OF 1980

750 KV
500 KV
345 KV
287 KV
230 KV
CONNECTING LINES
CROSSOVER LINES

COMPREHENSIVE FRAMEWORK STUDIES

LOWER COLORADO REGION

PRINCIPAL TRANSMISSION LINES

YEAR 1980

20 0 20 40 60 80

SCALE OF MILES

Previous reconnaissance studies have indicated that an augmentation of 1.8 million acre-feet would be required to meet the national obligation to Mexico by the year 2000. Other basin augmentation considerations include the rate of development in the Upper Colorado Region, the needs of the southern portion of the California Region, and the dependability of the supply from the Colorado River.

The long-term 60-year record (1906 to 1965) indicates the annual average virgin flow of the Colorado River at Lee Ferry, Arizona, to be 15.09 million acre-feet while the 35-year period of 1931 to 1965 indicates an average annual virgin flow of only 13.09 million acre-feet. This study utilizes the long-term 1906 to 1965 period of record, which also was used for estimating the available water supply in studies leading to authorization of the Colorado River Basin Project Act.

Augmentation proposals in the past have included surface water imports from various areas of surplus outside the Pacific Southwest Area, desalting of sea water, and precipitation management. Each of these alternatives should be fully explored prior to implementing an augmentation program.

Precipitation management is being studied as a possible source of water for augmentation. However, the potential magnitude of water quantity that might be provided by this method would be inadequate to meet long-range needs. If large scale weather modification becomes operational, it could reduce importation requirements.

Importation of surface water from areas of surplus is one alternative for meeting the water supply deficiency of the Region, as well as that of the remainder of the Pacific Southwest Area. Both private and public entities have made various proposals for studies of long-distance water transfers from areas of surplus, such as Canada and the Pacific Northwest. However, legislative constraints and the guidelines for framework studies preclude consideration of this alternative at this time. More specifically, the Secretary of the Interior is prohibited under Title II of the Colorado River Basin Project Act of September 30, 1968, for a period of 10 years from the date of the Act, from undertaking studies of any plan for the importation of water into the Colorado River Basin from any natural river drainage basin lying outside the States of Arizona, California, Colorado, New Mexico, and those portions of Nevada, Utah, and Wyoming that are in the natural drainage basin of the Colorado River.

The desalting of sea water remains as the one available source for large scale water importation which may be considered in the Type I studies and for which general cost information is available. Therefore, desalting was considered the source of additional water for the Region and the basis for the general magnitude of costs presented herein. Major factors in considering importation on a regional basis are: the water needs of the entire Pacific Southwest Area should be coordinated

into a comprehensive plan of which the Lower Colorado Region's augmentation needs would be an integral part; and exploration should be made of the possibilities of exchanging the desalted water for Colorado River water presently being conveyed to the coastal area of southern California, thereby, releasing Colorado River water for use within the basin. Future studies also should be directed toward the siting of major desalting facilities.

For the purpose of the Type I studies, the following assumptions were made: (1) the desalting facilities would be located along the southern California coast; (2) the water would be conveyed to Lake Mead; (3) the 1906 to 1965 period of record defines the availability of Colorado River water; (4) the initial importation to relieve the basin states of the Mexican Water Treaty burden would be a national obligation and would be implemented near the end of the 1980 to 2000 time frame; and (5) the 2.5 million acre-feet of ground-water overdraft would be greatly reduced by 2020.

The framework program provides for the importation, prior to the year 2000, of 2.25 million acre-feet of desalted sea water to the Lower Colorado River including 1.80 million acre-feet of water provided as a national obligation to relieve the basin of the Mexican Water Treaty burden and 0.45 million acre-feet of water as a regional program. It was assumed that the water would be conveyed from the southern California coast to Lake Mead. Lake Mead would provide seasonal regulatory storage allowing maximum use of the facilities, whereas, alternative reservoirs downstream do not contain adequate storage. The water quality benefits achieved through mixing high quality desalted water with Colorado River water would be extensive, and a portion of the increased costs for upstream delivery could be recovered through power generation at Hoover and Davis Dams. Though other alternatives should be considered in later studies, augmentation at Lake Mead would facilitate the evaluation of benefits to water quality and other aspects of the Colorado River.

If the initial water importation were in operation at year 2000, there would remain a regional annual water deficiency of about 0.44 million acre-feet which, without further augmentation, would increase to about 2.1 million acre-feet annually by 2020. It is recommended that between 2000 and 2020, additional importation facilities provide about 1.9 million acre-feet annually, thereby reducing the Region's annual deficiency to 0.17 million acre-feet. It is expected that some ground water overdraft will continue throughout the study period particularly in outlying basins remote from augmentation service areas.

Additional facilities would be included to convey the successive stages of imported water from the Colorado River to the areas of need, largely in the Gila Subregion. The location of the conveyance facilities should consider the possibility of encouraging population dispersement. Terminal regulatory reservoir storage having a capacity of

about 600,000 acre-feet would be required in the vicinity of the major demand centers. Such reservoirs also would provide additional 14,000 surface acres during the period for recreation opportunities and for fish and wildlife uses. See map following this page for potential water resource facilities between 1981 and 2020.

Tertiary treatment facilities would provide further treatment of 680,000 acre-feet of conventionally treated municipal and industrial water for reuse. The treatment of an additional 0.9 million acres of forest lands would increase annual water yield by 150,000 acre-feet. Augmentation of water supplies in the central Arizona area could provide, through water exchanges, additional water for use in upstream areas for municipal, industrial, and mineral production needs as well as for alleviating irrigation water deficiencies. Reservoir storage totaling 0.4 million acre-feet is provided to regulate flows for use in the upstream areas, largely in the Gila Subregion.

Water Quality

Without augmentation and/or salinity control measures, the penalty costs of the Colorado River water salinity to Lower Colorado and California Region economies may exceed $25 million annually in 2010 and even greater amounts by the year 2020, according to a recent study 1/. These costs result from yield reductions for irrigated agriculture, treatment costs for industrial users, the acceptance of undesirable effects or water softening expenditures for municipal users, and the indirect costs imposed upon secondary or supporting industries.

Importation of water to Lake Mead would have a major impact on the quality of Colorado River water. Such quality improvement would be accounted for as a primary benefit resulting from the importation program.

The imported water proposed for this program would primarily be utilized to meet withdrawal requirements within the Region. Special legislation would be required to authorize the use of imported water primarily for quality control purposes.

The water quality program includes several waste water treatment plants and reuse facilities at or near the places of use. Most notable among these is a 150 mgd desalting plant to treat drainage effluent for reuse in the Gila Subregion.

In addition, the land treatment and management program described in the following section will materially reduce the suspended sediment in the Region's surface water supply.

1/ Under preparation by the Environmental Protection Agency.

REGIONAL PROGRAM
1981-2020

Continued studies are proposed to assess the increasingly complex water quality problems anticipated. Maximum utilization of the water resources of the Region requires the ultimate in water quality control measures and treatment facilities.

Land Treatment and Management

Increased pressure on the land resources inherent in the expanding needs and demands of the Region's population will necessitate continuation of the early action land treatment and management program on 43.3 million acres. In most cases, the same acre may require treatment more than once during the 40-year period because of development of improved methods, or the limited life of the measure or practice installed.

Cropland--The continuation of the land treatment and management program on 420,000 acres is provided to maintain the productive capacity of the land.

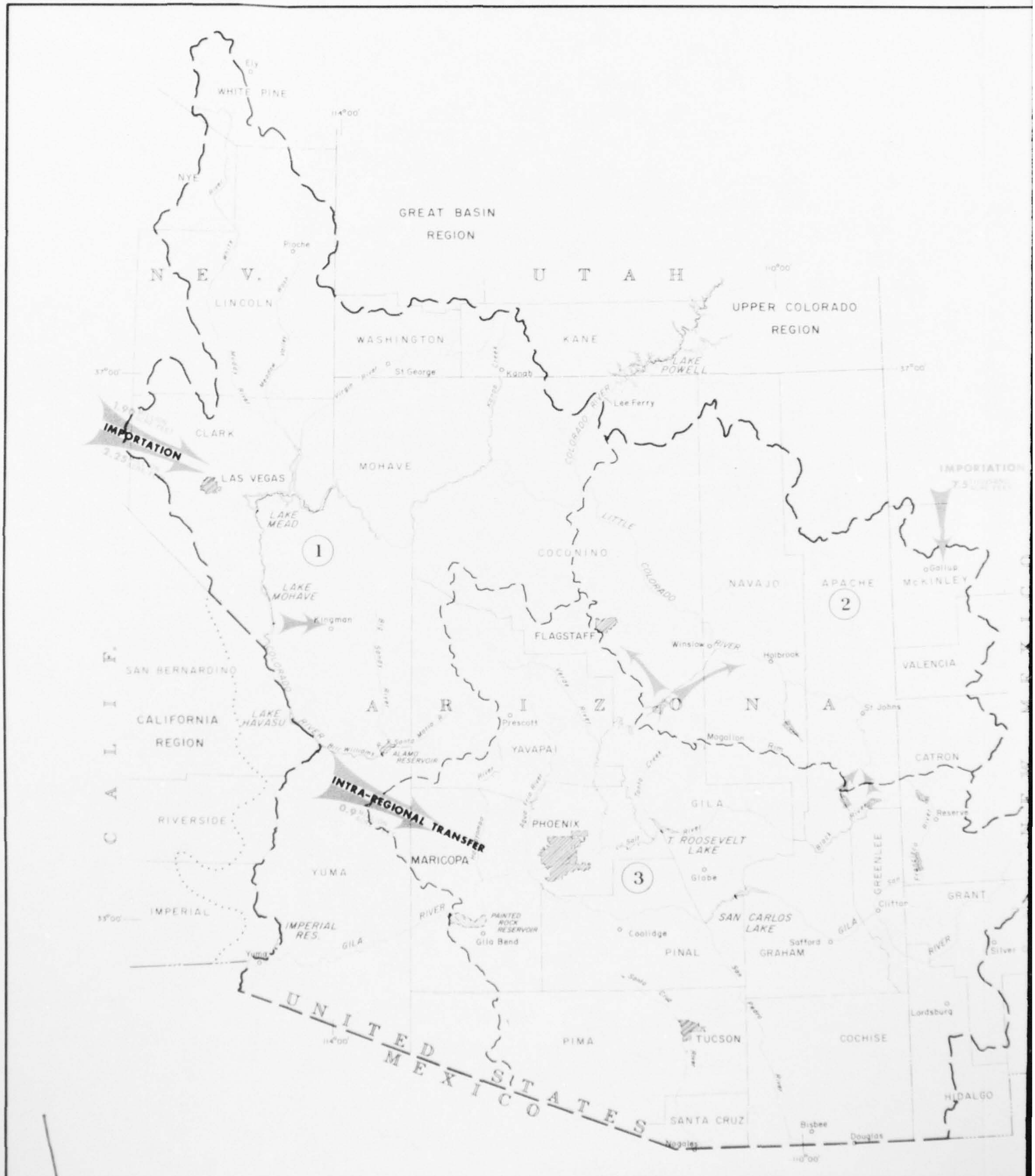
Rangeland--The land treatment and management program will be a continuation of the early action program. It will consist of watershed improvement, wildlife habitat improvement, increasing livestock forage, and improvement of recreation opportunities. Wildfire prevention and suppression will also continue throughout the projection periods. Land treatment practices are recommended on about 35 million acres of rangeland during the period 1981 to 2020.

Forest Land--Programs for meeting the demands for forest resources and uses by 2020 to meet the projected demands will require that about 40 percent of the forest resource potential be developed. This is equivalent to the development of about 7.6 million acres of forest lands during projection period from 1981 to 2020. The programs and measures for meeting the projected demands will include: watershed management, including water yield increase; protection of the forest environment and esthetics, in conjunction with the development and management of all other resources and uses; development of outdoor recreation facilities; maintaining and development of improved fish and wildlife habitat; improved management and increased carrying capacity of forest livestock grazing lands; and management of commercial timberlands to increase the production of timber products. See water yield map following page 200.

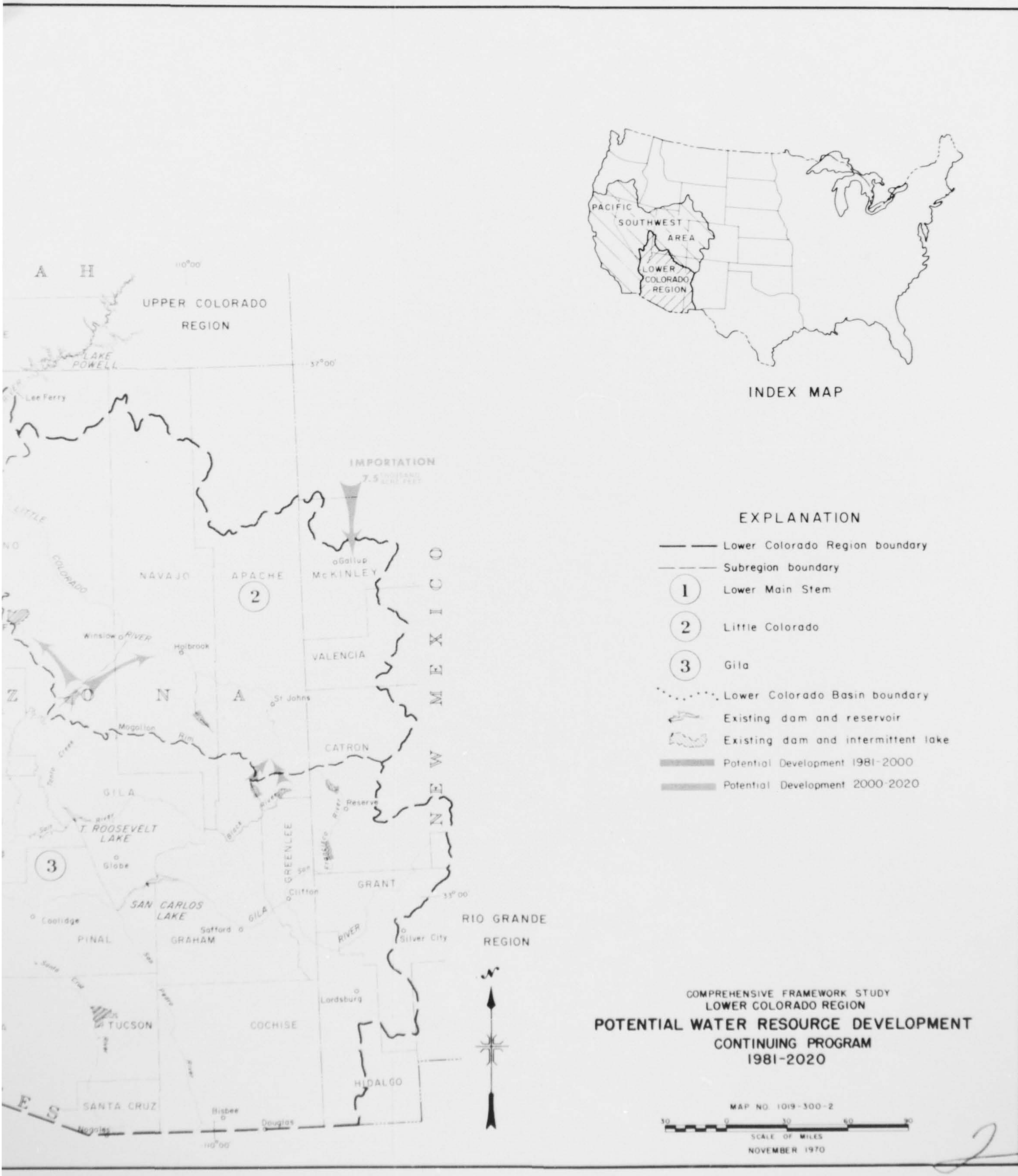
Urban and Other--About 510,000 acres of urban and other lands are included to receive land treatment and management between years 1981 and 2020.

Flood Control

The continued flood control program includes 97 upstream impoundments totaling 547,000 acre-feet storage, 385 miles of flood channel improvement, 89 miles of levees and land treatment practices for increased control of



GREAT BASIN REGION
UPPER COLORADO REGION
CALIFORNIA REGION
N E V.
U T A H
A R I Z O N A
C A L I F.
UNITED STATES
MEXICO
IMPORTATION
INTRA-REGIONAL TRANSFER
WHITE PINE
NYE
LINCOLN
CLARK
LAS VEGAS
WASHINGTON
KANE
MOHAVE
COCONINO
NAVAJO
APACHE
McKINLEY
VALENCIA
CATRON
FLAGSTAFF
YAVAPAI
PHOENIX
MARICOPA
GILA
YUMA
PINAL
GRAHAM
GREENLEE
PIMA
TUCSON
COCHISE
SANTA CRUZ
GRANT
HIDALGO
SAN BERNARDINO
RIVERSIDE
IMPERIAL
LAKE POWELL
LAKE MEAD
LAKE MOHAVE
LAKE HAVASU
T. ROOSEVELT LAKE
SAN CARLOS LAKE
IMPERIAL RES.
PAINTED ROCK RESERVOIR
ALAMO RESERVOIR
Ely
Pioche
St George
Kanab
Lee Ferry
Kingman
Prescott
Winslow
Holbrook
St Johns
Gallup
Globe
Coolidge
Gila Bend
Safford
Clifton
Reserve
Yuma
Bisbee
Douglas
Nogales
Lordsburg
Mogollon Rim
1
2
3



INDEX MAP
PACIFIC SOUTHWEST AREA
LOWER COLORADO REGION
UPPER COLORADO REGION
RIO GRANDE REGION
LAKE POWELL
Lee Ferry
IMPORTATION
NAVAJO
APACHE
McKINLEY
Gallup
VALENCIA
CATRON
GREENLEE
GRANT
GILA
GRAHAM
PINAL
COCHISE
SANTA CRUZ
HIDALGO
Winslow
Holbrook
St Johns
Mogollon Rim
Reserve
T. ROOSEVELT LAKE
Globe
SAN CARLOS LAKE
Clifton
Safford
Coolidge
Silver City
Lordsburg
TUCSON
Bisbee
Douglas
Nogales
NEW MEXICO
EXPLANATION
Lower Colorado Region boundary
Subregion boundary
1 Lower Main Stem
2 Little Colorado
3 Gila
Lower Colorado Basin boundary
Existing dam and reservoir
Existing dam and intermittent lake
Potential Development 1981-2000
Potential Development 2000-2020
COMPREHENSIVE FRAMEWORK STUDY
LOWER COLORADO REGION
POTENTIAL WATER RESOURCE DEVELOPMENT
CONTINUING PROGRAM
1981-2020
MAP NO. 1019-300-2
SCALE OF MILES
NOVEMBER 1970

floodwater, sediment, and erosion damage installed on 545,000 acres. Downstream facilities would provide 697,000 acre-feet of flood control storage, 150 miles of flood channel improvement, and 76 miles of levees. In addition, nonstructural measures and flood plain information reports on a priority of request basis would be provided for prevention of both upstream and downstream damages. The program is estimated to prevent annual flood damages so that the remaining upstream damages would amount to about $55 million annually and the downstream damages would amount to about $13 million annually. The Region's upstream and downstream total remaining damages at the end of the study period would total $68 million.

Municipal and Industrial Water

The program to meet long-range future needs of the Region includes augmentation of existing supplies, ground-water development, desalination of brackish supplies, and water reuse facilities.

Municipal and industrial water withdrawal requirements are expected to increase by about 2 million acre-feet between 1981 and 2020.

The most critically water-deficient area will continue to be in central Arizona where the depletion of ground water and a resulting increase in concentration of salts already have greatly degraded the ground-water resources. Transfer of farmland to urban and industrial uses probably will result in some water being transferred from agricultural to municipal uses. The major municipal water development would be participation in a regional water importation program. Completion of authorized facilities will meet the water needs of Las Vegas until about year 2000, after which a new supply will be needed. Desalting facilities having capacities totaling 123 million gallons per day are included in the program to treat brackish ground water for municipal use in 9 communities. An import of 7,500 acre-feet from the San Juan River is included for municipal use in Gallup, New Mexico. Multipurpose regulatory storage facilities in upstream areas would meet the needs of many of the Region's smaller communities. Continued development of ground-water supplies, with desalting where necessary, will meet the needs of most of the other small communities.

Irrigation and Drainage

It is assumed that rehabilitation of existing irrigation water conveyance systems, where required, will have been completed by 1980. It is estimated that during the period 1981 to 2020 about 176,000 acres of irrigated lands will be lost to urbanization. During this period a net gain of about 124,000 acres in irrigated area is predicted. To effectively utilize the imported water and to provide water to new lands, additional conveyance systems to serve about 730,000 acres would be required. Portions of these lands are now irrigated exclusively from ground water.

Water management measures for better control and more efficient use or irrigation water are recommended for installation on 1.6 million acres during the 1981 to 2020 period. These measures will be required for new land brought into production and there will be maintenance and replacement of existing measures because of limited life and/or increased technology.

With the addition of imported water supplies and increases in irrigated lands after 1980, it is expected that drainage facilities will be required to serve an additional 120,000 acres by year 2020.

Recreation

The continuing (1981 to 2020) recreation program will require the acquisition of 229,000 acres of land to satisfy projected needs for 234 million recreation days. An expenditure of $2 billion will be required for acquisition and development.

The water-associated recreation program would consist of additional facilities to utilize the full recreational opportunity of existing water projects along the Colorado River, which would satisfy the needs in that area. Multipurpose reservoirs in the Gila Subregion would make available about 39,000 surface acres of water for recreational use. There would remain an unmet need of almost 45,000 acres of water by the year 2020 to satisfy boating opportunity. Canal-side parks constructed in conjunction with the Arizona Aqueduct would partially meet recreation needs.

Under the framework plan only 234 million recreation days would be met at a cost of $858 million. The majority of recreation needs would largely remain unmet without modification of existing legal, institutional, and financial arrangements. These unmet needs would amount to about 293 million recreation days and $1,129 million for the period 1981 to 2020.

Fish and Wildlife

The multipurpose developments presently being considered for construction and improvement for the period 1981 to 2020 have the potential to provide approximately 1.0 million man-days of fishing of which about 60 percent would be expended within 75 miles of the major urban centers. Small primary-purpose impoundments having a total area of 32,440 acres are included in the program to meet the fishing demand during the 1981 to 2020 period.

Program-associated fishermen access facilities to assure optimum fishing use are provided in the program. Also, to stock the available habitat and that projected to meet fishing demands, the program provides for one cold water hatchery every 8 to 10 years and one warm water hatchery every 6 to 8 years.

A continuing 1981 to 2020 program for the development of wildlife resources is dependent upon the satisfactory effectuation of the early action program. The continuing program identifies 11.5 million acres needing more intensive management to yield maximum fish and wildlife values. The areas would be managed with emphasis directed to the production of fish and wildlife, with appropriate consideration of compatible and/or complementary uses. The identified areas include some of the more valuable wildlife habitat areas and some less important areas having the potential for development of habitat and located within reasonable-use distance of the major metropolitan areas.

This continuing program provides for the construction of primitive access roads and approximately 47,600 wildlife water devices to be developed on multipurpose as well as primary-purpose public lands.

Electric Power

Electric power requirements are projected to increase by thirteen-fold, from 8.3 gigawatts in 1980 to 108 gigawatts by 2020. The development program to meet these demands consists of transmission facilities for imports, fossil-fuel thermal plants, nuclear-fuel thermal plants, and pumped storage hydroplants.

Studies will be needed to determine where the power facilities should be located. Factors to be studied will include the costs of conveying cooling water to water-deficient areas versus the cost of transmitting energy longer distances; the hazards of thermal and nuclear pollution; conflicts with preservation of natural or scenic areas; and other environmental factors. Consideration will need to be given to the use of dry-type cooling in lieu of water cooling. The magnitude of increased electric power production needed will require close attention to design requirements for air and water pollution control measures.

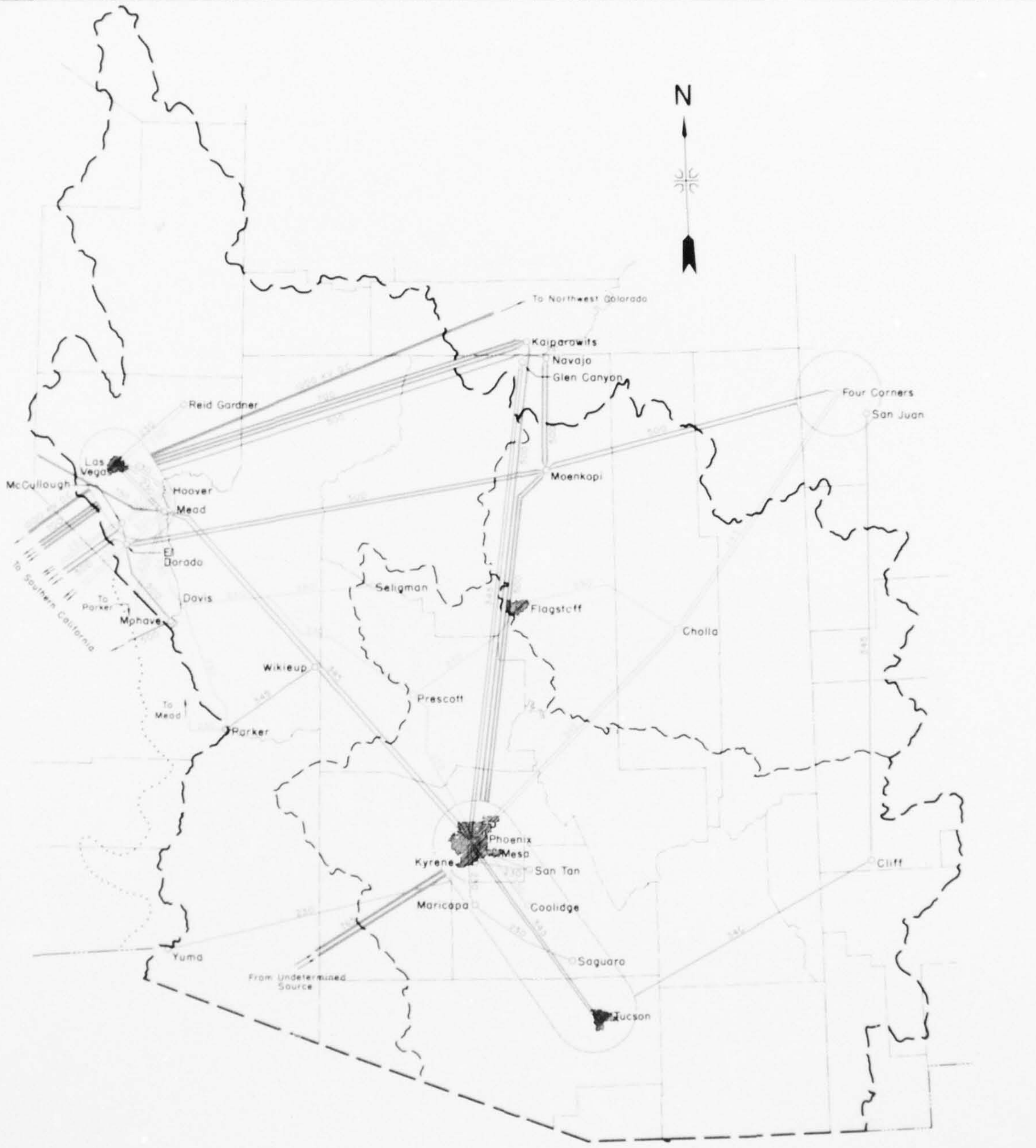
Conventional hydroelectric power plants are not included in the program.

Section 605 of Public Law 90-537 (Colorado River Basin Project Act) states that "Part I of the Federal Power Act (41 Stat. 1063; 16 USC 791a-823) shall not be applicable to the reaches of the main stream of the Colorado River between Hoover Dam and Glen Canyon Dam until and unless otherwise provided by Congress." Public Law 90-537 also prohibits construction as part of the Colorado River Project. Smaller hydroelectric projects have not been sufficiently investigated for recommendations at this time.

For principal transmission lines in years 2000 and 2020, see maps following.

REGIONAL PROGRAM
1981-2020

The following pages, XVIII-213 through XVIII-216 are summaries of the Lower Colorado Region framework program in terms of facilities required, program accomplishments, installation costs, and OM&R costs for the period 1965 to 2020.



LEGEND

TRANSMISSION LINES:

	PROJECTED AS OF 2000	AS OF JUNE 30, 1965
1000 KV D C		
765 KV		
700 KV		
500 KV		
345 KV		
287 KV		
230 KV		
CONNECTING LINES		
CROSSOVER LINES		

Notes:

1. No attempt has been made to forecast either additions or deletions of transmission facilities of less than 230 KV.
2. Transmission lines simplified in congested areas.

COMPREHENSIVE FRAMEWORK STUDIES

LOWER COLORADO REGION

PRINCIPAL TRANSMISSION LINES

YEAR 2000

20 0 20 40 60 80

SCALE OF MILES

LEGEND

TRANSMISSION LINES

	PROJECTED AS OF 2020	AS OF JUNE 30, 1965
1000 KV D.C.		
765 KV		
700 KV		
500 KV		
345 KV		
230 KV		
CONNECTING LINES		
CROSSOVER LINES		

Notes:

1. No attempt has been made to forecast either additions or deletions of transmission facilities of less than 230 KV.
2. Transmission lines simplified in congested areas.

COMPREHENSIVE FRAMEWORK STUDIES

LOWER COLORADO REGION

PRINCIPAL TRANSMISSION LINES

YEAR 2020

20 0 20 40 60 80

SCALE OF MILES

Table F-2
LOWER COLORADO REGION
PROGRAM FACILITIES
AND RESOURCE IMPROVEMENT

PROGRAM FUNCTION	UNITS	1966-1980 PROGRAM	1981-2000 PROGRAM	2001-2020 PROGRAM
MULTIPURPOSE WATER SUPPLY				
Reservoir Storage - Total	1,000 A.F.	3,710	1,315	280
Conservation Storage	1,000 A.F.	903	840	200
Recreation (Joint Use)	1,000 Ac.	36.4	9.1	5.0
Fish & Wildlife (Joint Use)	1,000 Ac.	36.4	9.1	5.0
Conveyance System & over 100 cfs	miles	304	617	617
Sea Water Desalting	mgd	--	2,800	2,200
Water Yield Improvement	1,000 Ac.	175	535	405
WATER QUALITY & POLLUTION CONTROL				
Conventional Waste Water Treatment	mgd	270	440	530
Tertiary Waste Water Treatment	mgd	260	320	360
Drainage Water Treatment	mgd	--	--	150
LAND TREATMENT & MANAGEMENT		19,263	26,706	16,560
Cropland (Acres Treated)	1,000 Ac.	(153)	(211)	(209)
Rangeland (Acres Treated)	1,000 Ac.	(15,328)	(21,567)	(13,219)
Forest Land (Acres Treated)	1,000 Ac.	(3,600)	(4,700)	(2,850)
Urban and Other (Acres Treated)	1,000 Ac.	(182)	(228)	(282)
FLOOD CONTROL				
Levees & Channels	miles	859	455	245
Reservoir & Detention Storage	1,000 A.F.	3,145	596	648
Land Treatment	1,000 Ac.	188	280	265
MUNICIPAL & INDUSTRIAL WATER				
Municipal Desalting Plants	No.	8	2	7
Municipal Desalting Plants	mgd	18	108	15
RECREATION				
Land Acquisition	1,000 Ac.	14	17	29
Federal Acreage Shift	1,000 Ac.	1,314	317	242
FISH AND WILDLIFE				
Wildlife Facilities	No.	1,000	15,900	31,700
Fish Habitat	1,000 Ac.	1.9	10.8	21.6
Hatcheries	No.	5	5	5
ELECTRIC POWER	GW	2.7	26.5	86.9
Pumped Storage	GW	(0.8)	(3.7)	(9.1)
Fossil-fuel Thermal	GW	(1.9)	(16.3)	(40.2)
Nuclear Thermal	GW	(0)	(6.5)	(37.6)

Table F-3 - Lower Colorado Region
PROGRAM ACCOMPLISHMENTS (Addition to 1965 Base)

PROGRAM FUNCTION	UNITS	1966-1980 PROGRAM	1981-2000 PROGRAM	2001-2020 PROGRAM
MULTIPURPOSE WATER SUPPLY				
Surface Water Development	1,000 AF/Yr	122	98	0
Importations	1,000 AF/Yr	--	2,250	1,900
National	1,000 AF/Yr	--	(1,800)	
Regional	1,000 AF/Yr	--	(450)	(1,900)
Water Salvage	1,000 AF/Yr	300	--	--
Intraregional Water Transfer	1,000 AF/Yr	1,670	3,000	1,080
Water Yield Improvement	1,000 AF/Yr	30	88	62
WATER QUALITY CONTROL				
Conventional Waste Water Treatment	mgd	270	440	530
Tertiary Waste Water Treatment	mgd	260	320	360
Drainage Water Treatment	mgd	--	--	150
LAND TREATMENT & MANAGEMENT				
Value Crop Production	$ million/yr	500	704	932
Erosion Damage Prevention	$1,000/yr	2,400	9,600	17,800
Wildfire Damage Prevention	$1,000/yr	1,035	3,169	7,969
Increased Grazing Capacity	1,000 AUM/yr	295	1,157	1,906
Increased Timber Harvest	Mil. CF/Yr	23	43	53
Decreased Sediment Yield	AF/Yr	2,723	7,165	11,093
FLOOD CONTROL - DAMAGE PREVENTION	$1,000/yr	32,500	102,000	242,000
IRRIGATION				
New Distribution System	1,000 Ac.	347	596	132
Rehabilitation of Distribution System	1,000 Ac.	429	--	--
Land Preparation, Onfarm Facilities	1,000 Ac.	573	801	779
DRAINAGE	1,000 Ac.	68	32	88
MUNICIPAL & INDUSTRIAL WATER				
Desalting Brackish Water	mgd	18	108	15
RECREATION	million recreation days/yr	51	119	115
FISH & WILDLIFE				
Fishing	1,000 man-days/yr	3,939	6,107	10,235
Hunting	1,000 man-days/yr	83	907	1,559
ELECTRIC POWER				
Capacity	GW	2.7	26.5	86.9
Energy	gwh/yr	7,100	80,420	365,600

Table F-4
LOWER COLORADO REGION
INSTALLATION COSTS
(Increments in each time frame in millions of dollars)

PROGRAM FUNCTION	1966-1980 PROGRAM Federal	1966-1980 PROGRAM Non-Federal	1981-2000 PROGRAM Federal	1981-2000 PROGRAM Non-Federal	2001-2020 PROGRAM Federal	2001-2020 PROGRAM Non-Federal
WATER SUPPLY--MULTIPURPOSE 1/	814.9	4.0	1,396.5	6.0	3,368.2	5.0
Importation (Regional)			(700)		(3,000)	
Intraregional Water Transfers	(729)		(592)		(338)	
Surface Water Development	(31.6)		(76.6)		--	
Water Salvage	(42.0)		--		--	
Water Yield Improvement	(12.3)	(4.0)	(26.9)	(6.0)	(30.2)	(5.0)
WATER QUALITY CONTROL	54	61	47	61	224	103
Conventional Waste Water Treatment	(41)	(50)	(44)	(58)	(63)	(102)
Tertiary Waste Water Treatment	(13)	(11)	(3)	(3)	(1)	(1)
Drainage Water Treatment	(0)	(0)	(0)	(0)	(160.0)	(0)
LAND TREATMENT AND MANAGEMENT	159.4	46.3	347.6	66.7	153.6	64.3
Cropland						
Erosion, Sediment and Runoff Control	(0.9)	(2.2)	(1.3)	(3.1)	(1.2)	(3.0)
Soil Survey	(0.4)		(0.5)		(0.5)	
Rangeland						
Erosion, Sediment and Runoff Control	(48.7)	(16.3)	(61.6)	(23.3)	(26.5)	(17.2)
Vegetative Management	(11.1)	(4.8)	(16.5)	(6.0)	(6.4)	(7.1)
Forest Land						
Erosion, Sediment and Runoff Control	(72.7)	(16.1)	(198.4)	(20.6)	(86.4)	(27.4)
Timber Production	(21.5)	(2.2)	(51.0)	(6.6)	(13.3)	(2.1)
Forage Production	(2.6)	(0.3)	(16.3)	(1.6)	(16.8)	(0.7)
Wildfire, Prevention and Suppression	(0.1)	(-)	(0.3)	(-)	(0.4)	(-)
Urban						
Erosion, Sediment and Runoff Control	(1.1)	(4.4)	(1.4)	(5.5)	(1.7)	(6.8)
FLOOD CONTROL	319.6	39.9	273.4	63.7	188.2	59.3
Levees and Channels	(97.0)	(13.2)	(177.4)	(27.7)	(52.3)	(3.6)
Reservoirs	(218.3)	(9.4)	(89.0)	(9.0)	(130.2)	(16.7)
Flood Plain Regulation	(0.8)	(14.5)	(0.7)	(23.0)	(0.5)	(32.9)
Land Treatment 2/	(3.5)	(2.8)	(6.3)	(4.0)	(5.2)	(6.1)
IRRIGATION	149.9	84.4	186.6	75.7	47.2	70.2
Irrigation Development	(76)	(32)	(172)	(12)	(33)	(8)
Rehabilitation of Distribution System	(63)	(7)	(-)	(-)	(-)	(-)
Land Preparation, Onfarm Facilities	(10.9)	(45.4)	(14.6)	(63.7)	(14.2)	(62.2)
DRAINAGE	13	1	14	1	44	1
MUNICIPAL AND INDUSTRIAL WATER	47	62	90	189	0	140
Desalting Brackish Water	(-)	(15)	(-)	(107)	(-)	(8)
Other Water Developments 3/	(-)	(47)	(-)	(82)	(-)	(142)
RECREATION	115.0	91.0	339.0	122.0	216.0	197.0
Development and Acquisition	(103)	(91)	(323)	(122)	(216)	(197)
Reservoirs (Joint Use)	(12)	(-)	(16.0)	(-)	(-)	(-)
FISH AND WILDLIFE	40.9	9.6	87.3	26.5	156.6	51.4
Fish	(15.4)	(8.2)	(29.4)	(9.8)	(54.8)	(18.2)
Wildlife	(8.6)	(1.3)	(50.1)	(16.7)	(100.6)	(33.2)
Multipurpose Reservoirs	(16.9)	(0.1)	(7.8)	(0)	(1.2)	(0)
ELECTRIC POWER		815		5,400		17,000
Power Plants		(305)		(3,000)		(11,000)
Transmission		(510)		(2,400)		(6,000)

1/ Does not include national obligation to relieve Colorado Basin States of Mexican Treaty burden at an estimated cost of $2.9 billion during the 1981 to 2000 time frame.
2/ Costs for this purpose are also included in several items of the Land Treatment and Management Program.
3/ Includes development of ground- and surface-water supplies and treatment plants.

Table F-5
LOWER COLORADO REGION
ANNUAL OPERATION, MAINTENANCE AND REPLACEMENT COSTS
(Cumulated above 1965 level at last year of time frame in thousands of dollars)

PROGRAM FUNCTION	1966-1980 PROGRAM		1981-2000 PROGRAM		2001-2020 PROGRAM	
	Federal	Non-Federal	Federal	Non-Federal	Federal	Non-Federal
WATER SUPPLY--MULTIPURPOSE	1,400	7,694	187,200	59,404	197,380	212,054
Importation:						
National Obligation	--		(170,000)		(170,000)	
Regional Program				(40,000)		(189,000)
Water Salvage	--		(1,000)		(1,000)	
Intraregional Water Transfers		(7,500)		(13,200)		(17,900)
Water Yield Improvement	1,400	180	16,200	6,150	26,380	5,100
Surface Water Development	--	(14)		(54)		(54)
WATER QUALITY CONTROL	387	7,792	854	20,374	1,559	39,035
Conventional Waste Water Treatment	387	5,392	854	12,774	1,559	27,735
Tertiary Waste Water Treatment	0	2,400	0	7,600	0	11,300
Drainage Water Treatment	(-)	(-)	(-)	(-)	(-)	(-)
LAND TREATMENT AND MANAGEMENT	19,961	6,129	35,203	11,169	48,563	8,436
Cropland						
Erosion, Sediment and Runoff Control	(95)	(233)	(100)	(238)	(98)	(237)
Soil Survey	-	-	-	-	-	-
Rangeland						
Erosion, Sediment and Runoff Control	(2,617)	(345)	(4,201)	(427)	(5,810)	(462)
Forage Production	(1,096)	(220)	(1,725)	(260)	(2,912)	(244)
Wildfire, Prevention and Suppression	(1,276)	(36)	(1,708)	(74)	(2,008)	(123)
Forest Land						
Erosion, Sediment and Runoff Control	(7,610)	(2,361)	(13,628)	(6,736)	(18,975)	(2,974)
Timber Production	(560)	(75)	(1,470)	(50)	(1,390)	(10)
Forage Production	(215)	(105)	(760)	(265)	(1,775)	(330)
Wildfire, Prevention and Suppression	(6,400)	(1,925)	(11,450)	(1,675)	(15,350)	(1,850)
Urban						
Erosion, Sediment and Runoff Control	(92)	(829)	(161)	(1,444)	(245)	(2,206)
FLOOD CONTROL	620	1,222	265	1,159	818	886
Levees and Channels	(12)	(385)	(0)	(457)	(0)	(236)
Reservoirs	(198)	(502)	(0)	(331)	(420)	(148)
Flood Plain Regulation	(195)	(77)	(115)	(117)	(0)	(165)
Land Treatment	(215)	(258)	(150)	(254)	(398)	(337)
IRRIGATION AND DRAINAGE	424	17,273	430	18,294	431	19,042
Irrigation Development		(9,330)		(9,908)		(10,118)
Drainage Development		(297)		(520)		(1,109)
Land Preparation, Onfarm Facilities	(424)	(7,646)	(430)	(7,866)	(431)	(7,815)
MUNICIPAL AND INDUSTRIAL WATER	-	4,770	-	22,380	-	28,230
RECREATION	9,500	8,800	39,500	20,900	63,000	41,000
FISH AND WILDLIFE	2,950	910	10,350	3,180	23,680	7,570
Fish	(1,210)	(600)	(3,150)	(1,240)	(6,340)	(2,310)
Wildlife	(1,000)	(200)	(6,070)	(1,830)	(16,150)	(5,150)
Multipurpose Reservoirs	(740)	(110)	(1,130)	(110)	(1,190)	(110)
ELECTRIC POWER	-	27,700	-	230,100	-	845,600
Power Plants	-	14,200	-	166,800	-	679,500
Transmission	-	(13,500)	-	(63,300)	-	(166,100)

LOWER MAIN STEM-
SUBREGION 1
FRAMEWORK PROGRAM

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LOWER COLORADO REGION COMPREHENSIVE FRAMEWORK STUDY. APPENDIX X--ETC(U)
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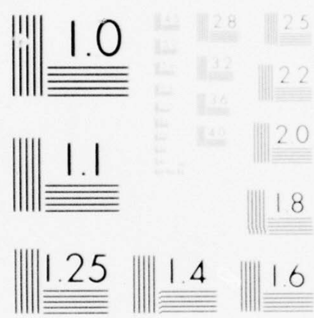

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

LOWER MAIN STEM SUBREGION

PROGRAM SUMMARY

The framework program developed to sustain a growing economy the Lower Main Stem Subregion is summarized in tables at the end this chapter.

Early Action Program, 1966 - 1980

Multipurpose Water Supply

The authorized Dixie Project in southwestern Utah will provi 5,000 acre-feet of water for municipal and irrigation uses, suppl mental irrigation water to 9,650 acres of presently developed lar and a full water supply for 6,900 acres of new land, plus 2,800 surface acres of water and 1,800 acres of land to satisfy fishery recreation needs in that area.

The authorized Colorado River Basin Project contains measure continuance of water salvage activities along the main stem of th Colorado River. Authorized measures include removal of some of t phreatophytes within the river flood plain and a ground-water rec program in the Yuma, Arizona, area. Maintenance of the Colorado channel in reaches downstream from Davis Dam will also be continu The multipurpose role of the Colorado River in providing a vital of water for cities and agriculture as well as its role in the pr gation of wildlife, and its utilization to provide fishing and ot recreation opportunities, will continue to be the object of const and management programs. Water salvage measures, including veget management, along the Colorado River and along the Gila River are expected to provide an additional 270,000 acre-feet of water for the Lower Colorado River Basin.

Water Quality

To help forestall the imminent consequences of further deter oration of Colorado River water, the early action program include elimination of the saline flow from LaVerkin Springs on the Virgi River in Utah and the construction and operation of a tertiary tr plant in the Las Vegas area. Effluent from the latter could be u to meet some of the water requirements in the Las Vegas area for try, recreation, and power generation. LaVerkin Springs now cont about 100,000 tons of salt or about 1 percent of the total salt l

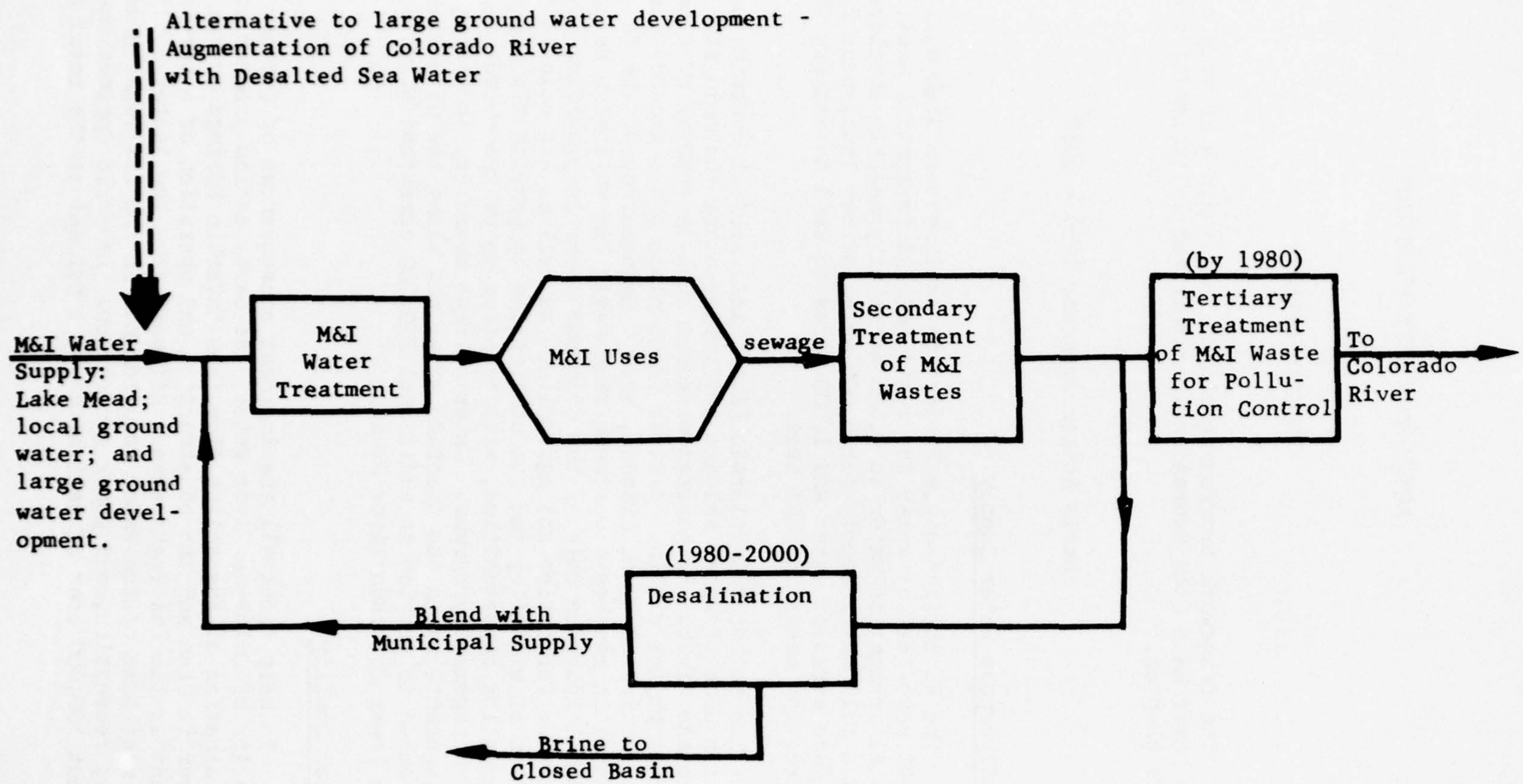

Figure F-1- Schematic Diagram of Program for Water Use and Reuse in Clark County, Nevada

reaching Lake Mead annually. Figure F-1 schematically diagrams the program for water use, treatment, and reuse in Clark County, Nevada.

Land Treatment and Management

The program includes treatment of 7.7 million acres by 1980 at a total cost of $39.7 million. Of the total program, 1 percent of the cost will be on cropland, 51 percent on rangeland, 44 percent of forest land, and 4 percent on urban and other lands. Measures for erosion, sediment, and runoff control will be provided on 34,000 acres of cropland during the period. About 7.0 million acres of rangeland; 670,000 acres of forest land; and 56,000 acres of urban and other lands will be adequately treated during this period. The recommended land treatment and management program by land resource group is explained in the regional write-up on page

Flood Control

Flood Control storage facilities of 1.06 million acre-feet capacity, together with 285 miles of channel improvement and levees, land treatment practices, and nonstructural measures, are provided for in the early action program. Damages prevented would total about $9.1 million. Annual flood damages of $11.4 million will not be prevented in 1980 even with this program in operation.

Irrigation and Drainage

Construction of irrigation water conveyance facilities to serve 128,000 acres is provided for in the early action program, including irrigation facilities provided in the authorized Dixie Project and those required to serve lands on the Mohave and Colorado River Indian Reservations. Onfarm irrigation water management measures are recommended for installation on 128,000 acres of irrigated land by 1980. Additional irrigation development on the Indian Reservations will greatly improve the economy of these economically depressed areas. Estimated cost is $68.1 million for the early action program.

Drainage facilities would be provided to serve 67,000 acres of land, mostly on the Colorado River Indian Reservation and in the Yuma area. Cost of the early action drainage program is $13 million.

Municipal and Industrial Water Supply

The much needed first phase of the Southern Nevada Water Project now under construction is expected to be completed in 1971. The first phase will provide 132,000 acre-feet of municipal and industrial water for use in the Las Vegas area, alleviating to a large extent a ground-water overdraft in southern Nevada and providing for a continued rapid growth during the 1965 to 1980 period comparable to that experienced by the area in recent years.

A desalting plant is provided to improve the quality of water available for municipal uses in the Yuma area. Estimated cost of the municipal and industrial water supply program to 1980 is $76 million.

It is assumed that municipal and industrial water requirements of most of the smaller communities in the Subregion would be met by continued development of ground-water supplies.

Recreation

The Lake Mead National Recreation Area, for example, as well as the remaining reaches of the Colorado River, provides the major fresh water-oriented recreation area in the Southwest. Continued development of user facilities is needed to meet a rapidly increasing demand. Continued implementation of the Lower Colorado River Land Use Plan could provide about 20 million recreation days in the area downstream from Davis Dam. Continuance of recreation-oriented development on Indian-owned lands also is planned in the early action program, providing employment opportunities and economic benefits that help to alleviate poverty problems existing on the reservations.

The recreation needs for the Lower Main Stem Subregion to year 1980 will require the acquisition of 24,000 acres of land to satisfy the need for 43 million recreation days. Acquisition and development would require an expenditure of $172 million. The framework plan will accomplish development and land acquisition to meet 15.5 million recreation days of use at a cost of $56 million.

Fish and Wildlife

The construction of the authorized Central Arizona Project, Alamo Reservoir, Dixie Project, and the development of backwaters of the Colorado River are expected to add 410,000 man-days of fishing annually to the Subregion. Additional habitat is provided for in the early action program that will provide 710,000 man-days of fishing annually. A cold water fish hatchery is expected to be constructed by 1980.

Also included in the program are access and public-use facilities to assure optimum use of the habitat expected to be available by 1980. Management programs recently initiated at Lake Mead and other programs planned for the Colorado River, Lake Mohave, and Lake Havasu will help sustain a quality fishery.

Preservation and improvement of riparian and wetland areas along reaches of the Colorado, Virgin, Bill Williams, Big Sandy, Santa Maria, and Gila Rivers are important for sustaining wildlife and satisfying the demands. In addition to accelerating development and increasing wildlife production on public lands, it has been determined that approximately 145,800 acres need to be managed with appropriate consideration

of compatible and/or complementary uses, to yield maximum fish and wildlife values.

The development of access roads and the construction of approximately 500 wildlife watering facilities within the Lower Main Stem Subregion should be accomplished in this early action program. The cost of installation for the fish and wildlife program to 1980 is estimated at $18.7 million.

Electric Power

A 1,580 megawatt fossil-fuel thermal power plant is now under construction along the Colorado River in Nevada. This and other power plants will provide about 1,900 megawatts of generating capacity and about 7,100 gigawatt hours of energy annually to the Lower Colorado Region by 1980. The estimated cost is $229 million.

Continuing Program, 1981 - 2020

Multipurpose Water Supply

Annual net water requirements in the Subregion are projected to exceed the water supply by 0.47 million acre-feet by 2000. The deficiency is expected to increase to 1.1 million acre-feet by 2020. It is recommended that an importation program provide 0.25 million acre-feet annually for use in the Subregion beginning in the latter part of the 1981 to 2000 time period and increasing to 1.0 million acre-feet annually prior to the year 2020.

Water Quality

Waste water treatment facilities would be provided to prevent pollution from municipal sources. Intensification of water resources development, population growth and industrial expansion will result in increased depletions of the Colorado River which also will lower the quality of the Colorado River even if the salinity control programs and measures are implemented. The Colorado River Basin salinity control programs are sufficient to offset the projected degradation by about 27 percent at Hoover Dam and by about 38 percent at Imperial Dam. The regional water importation program provides inflow at Lake Mead which will also help offset such degradation.

Land Treatment and Management

Increased pressure on land resources inherent in the Subregion's growing population will require a continuation of early action land treatment and management practices on an additional 14.0 million acres by 2020.

LOWER MAIN STEM PROGRAM
1981-2020

Total estimated cost of the continuing land treatment and management program for the Lower Main Stem Subregion is $196.0 million.

Flood Control

Projected growth will require the addition, between 1981 and 2020, of 193,000 acre-feet of flood detention storage, 112 miles of levees and channel improvements, land treatment practices on 545,000 acres, and nonstructural measures to prevent flood damages so that the remaining flood damages in 2020 would total about $19.6 million annually.

Irrigation and Drainage

Facilities to convey water for irrigating about 51,000 acres of land are included in the 1981 to 2020 program. A small amount of additional irrigated agriculture is expected to be developed by private interests in outlying ground-water basins, and the remainder would be largely on Indian reservations. Irrigation on the Indian reservations is expected to decline during the later stage of the study period as urban and recreational development displaces agriculture. Water management measures to provide for better control and more efficient use of irrigation water are recommended for installation on 415,000 acres during the 1981 to 2020 period. Drainage facilities are included to serve 56,000 acres of irrigated lands. Estimated cost of the irrigation and drainage program for the 1981 to 2020 period is $27 million.

Municipal and Industrial Water Supply

Completion of the second stage of the Southern Nevada Water Project by the middle of the 1981 to 2000 time period is recommended to provide a total of 312,000 acre-feet of water for municipal and industrial uses. Treatment of a portion of the municipal wastes to provide water of suitable quality for some industrial and recreational uses is also included in this time frame. A diversion of about 22,000 acre-feet of water from the Colorado River is included to provide for increased municipal requirements in Kingman, Arizona. It is assumed that local ground-water development would continue to serve the needs of the smaller communities. The remaining municipal and industrial water needs would be supplied by the importation of water from outside the Region and would be needed by year 2000. The municipal and industrial water supply program for the Lower Main Stem Subregion during the 1981 to 2020 period is $246 million.

Recreation

Recreation development is expected to continue to concentrate along the Colorado River. Additional facilities would be constructed within the Lake Mead National Recreation Area, implementation of the Lower Colorado

River Land Use Plan 1/ would be completed, and considerable development would occur on the Mohave and Colorado River Indian Reservations.

The recreation needs for the Lower Main Stem Subregion, 1981 to 2020, require the acquisition of 83,000 acres of land to satisfy 175 million recreation days. Estimated cost for acquisition and development for the period would be $664 million. The framework plan will accomplish development and land acquisition to meet 69 million recreation days of use at a cost of $233 million.

Fish and Wildlife

The 1981 to 2020 program includes the development of small fishing lakes totaling 12,400 acres mainly within and adjacent to the population cneters of Las Vegas and Yuma and adjacent to the Colorado River. No multiple-purpose reservoirs are planned.

Other developments included in the program are two fish hatcheries and fishermen access and other public-use facilities. These developments and improved management of the available waters will help sustain a quality fishery.

A continuing wildlife program for the Lower Main Stem Subregion depends upon intensively managing approximately 9.4 million acres of mostly public lands to yield maximum fish and wildlife production and values with appropriate consideration of compatible and/or complementary uses. Also, accelerating wildlife development and increasing production on other public lands having wildlife values will be required. The development of access roads and 12,800 wildlife watering facilities are included in the 1981 to 2020 program.

Estimated cost of the 1981 to 2020 fish and wildlife program is $95.5 million.

Electric Power

A potential exists for developing more than 2 million kilowatts of hydroelectric capacity on the Colorado River. However, this potential capacity has not been recommended for development because of prohibitions contained in Public Law 90-537 (Colorado River Basin Project). The value of the power foregone by the elimination of these Colorado River hydroelectric projects is estimated at $52.6 million annually ($15.30 per kilowatt per year and 3.0 mills per kilowatt-hour). But more important is the electric power generation foregone that must be supplied

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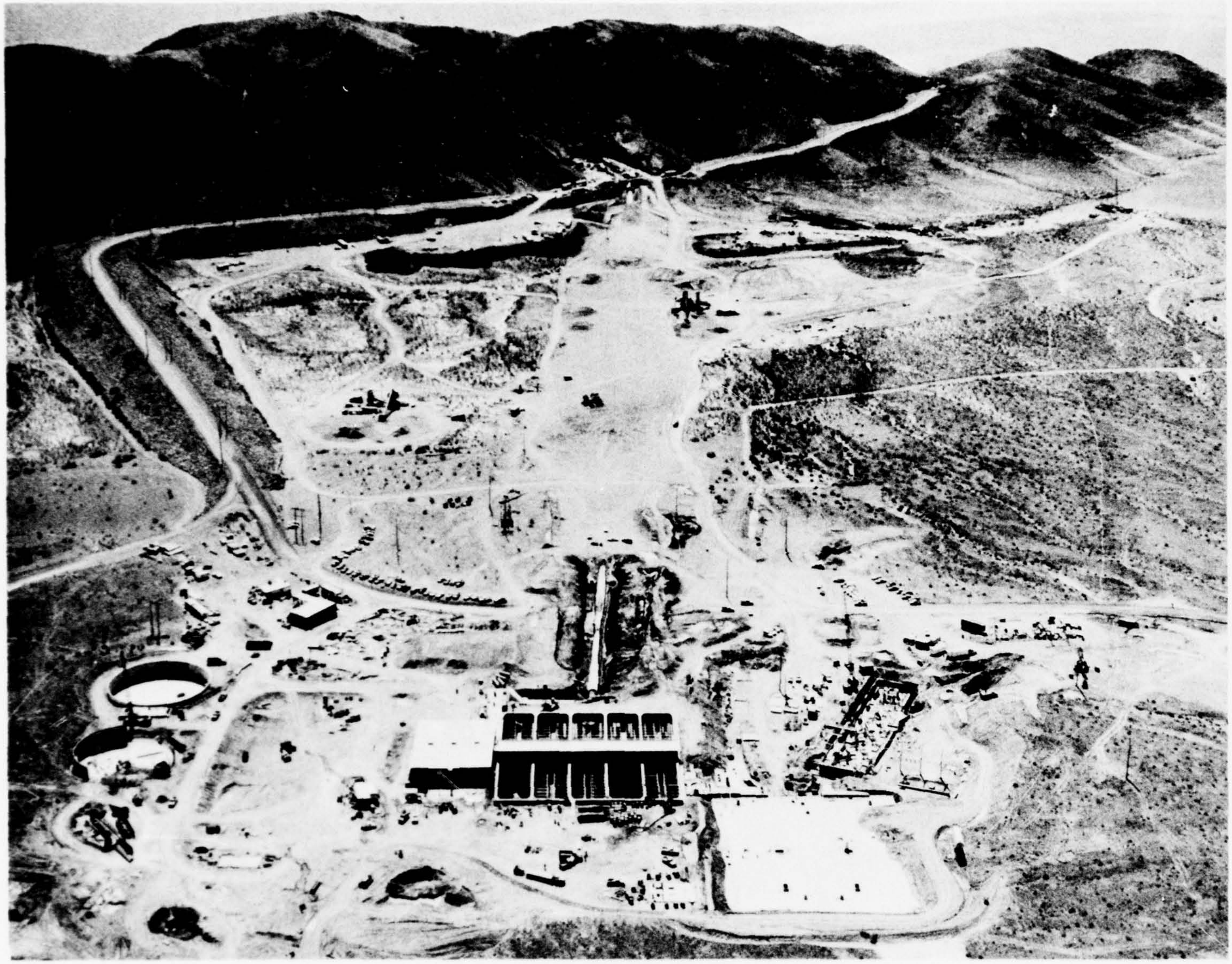
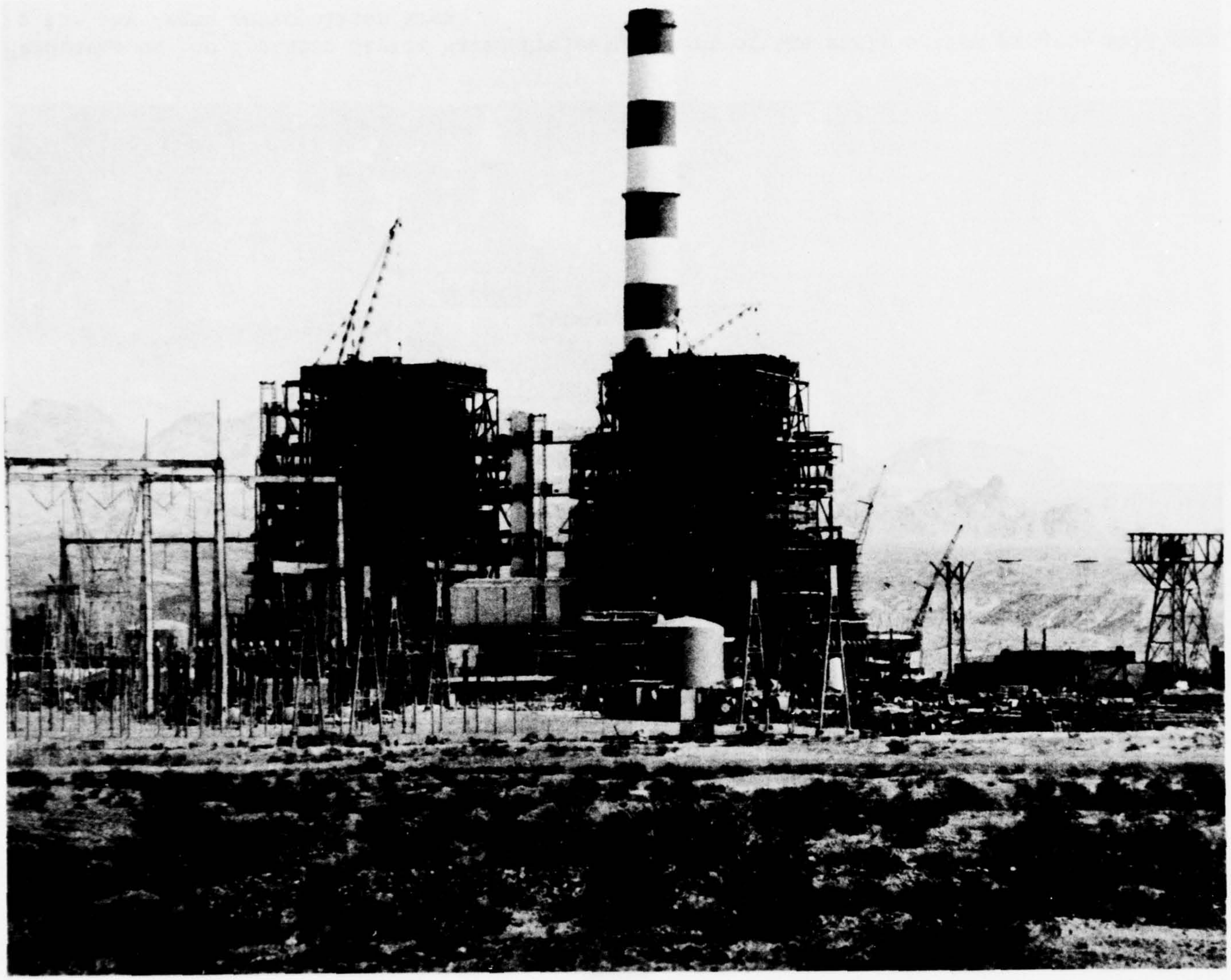
1/ The Lower Colorado River Land Use Plan, January 1964, United States Department of the Interior.

from other sources if the tremendous increase in electric power demands is to be met. It may be desirable for the relative environmental effects of various combinations of electric power generation to be considered before final decisions are reached. The 1981 to 2020 electric power program for the Lower Main Stem Subregion provides for installation of power plants having 25.2 gigawatts generating capacity. The estimated cost of power plants and transmission systems is $4.7 million.

The following pages, XVIII-227 through XVIII-230 are summaries of the Lower Main Stem framework program in terms of facilities required, program accomplishments, installation costs, and operation, maintenance, and replacement costs for the period 1966 to 2020.



Headworks of the Southern Nevada Water Project, a part of the early action program will supply water to the Las Vegas metropolitan area



Mohave power plant under construction, fossil-fueled, located on the Colorado River at the southern tip of Nevada, has a rated capacity of 1,580 megawatts of power

Table F-6
LOWER MAIN STEM SUBREGION
PROGRAM FACILITIES
AND RESOURCE IMPROVEMENT

PROGRAM FUNCTION	UNITS	1966-1980 PROGRAM	1981-2000 PROGRAM	2001-2020 PROGRAM
MULTIPURPOSE WATER SUPPLY				
Conservation Storage	1,000 A.F.	333.6	0	0
Recreation (Joint Use)	1,000 Ac.	14.3	0	0
Fish & Wildlife (Joint Use)	1,000 Ac.	14.3	0	0
Water Yield Increase	1,000 Ac.		10	30
WATER QUALITY CONTROL				
Conventional Waste Water Treatment	mgd	110	200	120
Tertiary Waste Water Treatment	mgd	50	70	0
LAND TREATMENT & MANAGEMENT	1,000 Ac.	7,729	10,296	3,657
Cropland (Acres Treated)	1,000 Ac.	(34)	(54)	(56)
Rangeland (Acres Treated)	1,000 Ac.	(6,969)	(9,263)	(2,912)
Forest Land (Acres Treated)	1,000 Ac.	(670)	(900)	(600)
Urban & Other (Acres Treated)	1,000 Ac.	(56)	(79)	(89)
FLOOD CONTROL				
Levees & Channels	miles	285	101	11
Reservoir & Detention Storage	1,000 A.F.	1,057	147	46
Land Treatment	1,000 Ac.	23	31	31
MUNICIPAL & INDUSTRIAL WATER				
Municipal Desalting Plants	mgd	10.5	100.0	1.0
RECREATION				
Land Acquisition	1,000 Ac.	4.7	7.9	8.8
Federal Acreage Shift	1,000 Ac.	892.2	6.9	12.8
FISH & WILDLIFE				
Wildlife Facilities	No.	500	6,700	6,100
Fish Habitat	1,000 Ac.	1.8	6.8	5.6
Hatcheries	No.	1	1	1
ELECTRIC POWER				
Pumped Storage	GW	0	0	5.0
Fossil-fuel Thermal	GW	1.9	3.9	8.7
Nuclear Thermal	GW	0	1.5	6.1

Table F-7 - Lower Main Stem Subregion
PROGRAM ACCOMPLISHMENTS (Addition to 1965 Base)

PROGRAM FUNCTION	UNITS	1966-1980 PROGRAM	1981-2000 PROGRAM	2001-2020 PROGRAM
MULTIPURPOSE WATER SUPPLY				
Importations	1,000 AF/Yr	0	320	580
Surface Water Development	1,000 AF/Yr	50	0	0
Water Salvage	1,000 AF/Yr	270	--	--
Water Yield Improvement	1,000 AF/Yr	1/	--	1
WATER QUALITY CONTROL				
Conventional Waste Water Treatment	mgd	110	200	120
Tertiary Waste Water Treatment	mgd	50	70	0
LAND TREATMENT & MANAGEMENT				
Value Crop Production	$ million/yr	140	195	269
Erosion Damage Prevention	$1,000/yr	600	2,700	4,900
Wildfire Damage Prevention	$1,000/yr	--	--	--
Increased Grazing Capacity	1,000 AUM/Yr	79	185	282
Increased Timber Harvest	Mil. CF/Yr	2	4	7
Decreased Sediment Yield	AF/Yr	824	1,769	2,987
FLOOD CONTROL - DAMAGE PREVENTION	$1,000/yr	9,130	29,200	57,400
IRRIGATION				
New Distribution System	1,000 Ac.	127	17	34
Rehabilitation of Distribution System	1,000 Ac.	103	0	0
Land Preparation, Onfarm Facilities	1,000 Ac.	128	207	208
DRAINAGE	1,000 Ac.	67	18	38
MUNICIPAL & INDUSTRIAL WATER				
Desalting Brackish Water	mgd	10.5	100.0	1.0
RECREATION	million recreation days/yr	15.5	28.7	40.2
FISH & WILDLIFE				
Fishing	1,000 man-days/yr	1,120	3,520	4,277
Hunting	1,000 man-days/yr	68	505	378
ELECTRIC POWER				
Capacity	GW	1.9	5.4	19.8
Energy	gwh/yr	6,650	16,900	71,400

1/ Included in water salvage figures.

Table F-8
LOWER MAIN STEM SUBREGION
INSTALLATION COSTS
(Increments in each time frame in millions of dollars)

PROGRAM FUNCTION	1966-1980 PROGRAM		1981-2000 PROGRAM		2001-2020 PROGRAM	
	Federal	Non-Federal	Federal	Non-Federal	Federal	Non-Federal
WATER SUPPLY--MULTIPURPOSE	73.6	0	5.4	1.0	5.2	0.5
Surface Water Development	(31.6)	(0)	(0)	(0)	(0)	(0)
Water Salvage	(42.0)	(0)	(0)	(0)	(0)	(0)
Water Yield Improvement	(-)	(-)	(5.4)	(1.0)	(5.2)	(0.5)
WATER QUALITY CONTROL	22	20	14	16	20	25
Conventional Waste Water Treatment	(10)	(10)	(12)	(14)	(20)	(25)
Tertiary Waste Water Treatment	(12)	(10)	(2)	(2)	(0)	(0)
LAND TREATMENT AND MANAGEMENT	31.8	7.9	85.7	11.3	34.0	13.0
Cropland						
Erosion, Sediment and Runoff Control	(0.1)	(0.2)	(0.1)	(0.2)	(0.1)	(0.3)
Soil Survey	(0.1)	(-)	(0.1)	(-)	(0.1)	(-)
Rangeland						
Erosion, Sediment and Runoff Control	(13.2)	(2.9)	(17.2)	(4.2)	(5.4)	(3.0)
Forage Production	(3.7)	(0.5)	(5.7)	(0.7)	(0.9)	(0.9)
Forest Land						
Erosion, Sediment and Runoff Control	(12.0)	(3.0)	(55.9)	(3.8)	(21.4)	(6.6)
Timber Production	(1.6)	(-)	(3.2)	(0.4)	(0.9)	(-)
Forage Production	(0.7)	(-)	(2.8)	(0.1)	(4.5)	(0.1)
Wildfire, Prevention and Suppression	(-)	(-)	(0.1)	(-)	(0.1)	(-)
Urban						
Erosion, Sediment and Runoff Control	(0.3)	(1.3)	(0.5)	(1.9)	(0.5)	(2.1)
FLOOD CONTROL	69.2	6.5	49.3	14.1	12.7	8.4
Levees and Channels	(29.2)	(1.2)	(25.4)	(4.2)	(4.5)	(0.6)
Reservoirs	(39.5)	(1.9)	(22.6)	(4.3)	(7.0)	(0.5)
Flood Plain Regulation	(0.1)	(3.2)	(0.2)	(5.1)	(0.1)	(6.5)
Land Treatment 1/	(0.4)	(0.2)	(1.1)	(0.5)	(1.1)	(0.8)
IRRIGATION	45.8	22.3	7.7	17.0	12.7	18.3
Irrigation Development	(28)	(11)	(4)	(1)	(9)	(2)
Rehabilitation of Distribution Systems	(15)	(2)	(0)	(0)	(0)	(0)
Land Preparation, Onfarm Facilities	(2.8)	(9.3)	(3.7)	(16.0)	(3.7)	(16.3)
DRAINAGE	12	1	3	1	7	0
MUNICIPAL AND INDUSTRIAL WATER	47	29	51	128	0	67
Desalting Brackish Water	(0)	(8)	(0)	(100)	(0)	(1)
Other Water Development	(47)	(21)	(51)	(28)	(0)	(66)
RECREATION	33.2	29.0	46.2	52.4	79.2	55.3
Land Acquisition and Development	(27.2)	(29.0)	(46.2)	(52.4)	(79.2)	(55.3)
Reservoirs (Joint Use)	(6.2)	(-)	(-)	(-)	(-)	(-)
FISH AND WILDLIFE	16.1	2.6	38.2	12.8	33.4	11.1
Fish	(9.2)	(2.3)	(16.9)	(5.7)	(13.9)	(4.6)
Wildlife	(6.0)	(0.2)	(21.3)	(7.1)	(19.5)	(6.5)
Multipurpose Reservoirs	(0.9)	(0.1)	(0)	(0)	(0)	(0)
ELECTRIC POWER		229		610		2,400
Power Plants		(229)		(610)		(2,400)

1/ Costs for this purpose also included several items of the land treatment and management program.

Table F-9
LOWER MAIN STEM SUBREGION
ANNUAL OPERATION, MAINTENANCE AND REPLACEMENT COSTS
(Cumulated above 1965 level at last year of time frame in thousands of dollars)

PROGRAM FUNCTION	1966-1980 PROGRAM		1981-2000 PROGRAM		2001-2020 PROGRAM	
	Federal	Non-Federal	Federal	Non-Federal	Federal	Non-Federal
WATER SUPPLY--MULTIPURPOSE	150	1,014	2,200	1,514	3,380	1,564
Surface Water Development	(-)	(14)	(-)	(14)	(-)	(14)
Water Salvage	(-)	(1,000)	(-)	(1,000)	(-)	(1,000)
Water Yield Improvement	(150)	(-)	(2,200)	(500)	(3,380)	(550)
WATER QUALITY CONTROL	100	2,450	235	8,535	470	14,740
Conventional Waste Water Treatment	(100)	(1,250)	(235)	(3,135)	(470)	(7,140)
Tertiary Waste Water Treatment	(0)	(1,200)	(0)	(5,400)	(0)	(7,600)
LAND TREATMENT AND MANAGEMENT	3,605	447	6,430	826	9,531	1,022
Cropland						
Erosion, Sediment and Runoff Control	(7)	(17)	(8)	(18)	(8)	(19)
Soil Survey	(-)	(-)	(-)	(-)	(-)	(-)
Rangeland						
Erosion, Sediment and Runoff Control	(786)	(41)	(1,273)	(43)	(1,640)	(42)
Forage Production	(334)	(30)	(671)	(26)	(920)	(30)
Wildfire, Prevention and Suppression	(336)	(4)	(484)	(8)	(570)	(12)
Forest Land						
Erosion, Sediment and Runoff Control	(1,481)	(95)	(2,861)	(235)	(4,563)	(185)
Timber Production	(105)	(-)	(260)	(-)	(305)	(-)
Forage Production	(55)	(15)	(135)	(40)	(375)	(40)
Wildfire, Prevention and Suppression	(725)	(-)	(1,050)	(-)	(1,500)	(-)
Urban						
Erosion, Sediment and Runoff Control	(28)	(248)	(51)	(462)	(78)	(702)
FLOOD CONTROL	149	220	33	219	108	97
Levees and Channels	(12)	(76)	(0)	(72)	(0)	(14)
Reservoirs	(75)	(109)	(0)	(103)	(0)	(30)
Flood Plain Regulation	(45)	(18)	(15)	(26)	(0)	(34)
Land Treatment	(17)	(17)	(18)	(18)	(108)	(19)
IRRIGATION AND DRAINAGE	120	3,994	137	4,279	139	4,575
Irrigation Development	(-)	(2,110)	(-)	(2,200)	(-)	(2,380)
Drainage Development	(-)	(277)	(-)	(293)	(-)	(337)
Land Preparation, Onfarm Facilities	(120)	(1,607)	(137)	(1,786)	(139)	(1,858)
MUNICIPAL AND INDUSTRIAL WATER	-	2,690	-	18,100	-	20,900
RECREATION	3,300	2,300	9,500	7,200	20,200	11,900
FISH AND WILDLIFE	1,710	335	3,040	1,013	2,730	910
Fish	(825)	(275)	(940)	(313)	(780)	(260)
Wildlife	(550)	(50)	(2,100)	(700)	(1,950)	(650)
Multipurpose Reservoirs	(335)	(10)	(0)	(0)	(0)	(0)
ELECTRIC POWER	-	12,500	-	34,200	-	116,600
Power Plants	(-)	(12,500)	(-)	(34,200)	(-)	(116,600)

LITTLE COLORADO

SUBREGION 2

FRAMEWORK PROGRAM

LITTLE COLORADO SUBREGION

PROGRAM SUMMARY

The framework program developed to meet the present and future needs of the Little Colorado Subregion is summarized in tables at the end of this chapter.

Early Action Program, 1966 - 1980

Multipurpose Water Supply

It is recommended that further studies evaluate the ground-water potential as an alternative to surface-water development to meet future water needs of this Subregion.

Treatment of 65,000 acres for increased water yield of 5,000 acre-feet annually is recommended during this period.

Water Quality

Additional waste water treatment facilities to serve the expanding urban population are included in the early action program.

Land Treatment and Management

The program includes treatment of 4.0 million acres by 1980 at a total cost of $56.2 million. Of the total program, 1 percent of the cost will be on cropland, 17 percent on rangeland, 81 percent on forest land, and 1 percent on urban and other lands. Measures for erosion, sediment, and runoff control will be provided on 3,000 acres of cropland during the period. About 3.1 million acres of rangeland; 930,000 acres of forest land; and 19,000 acres of urban and other lands will be adequately treated during this period. The recommended land treatment and management program by land resource group is explained in the regional write-up on page

Flood Control

The flood control program includes 20 upstream impoundments with capacity totaling 109,000 acre-feet. In addition, 51 miles of channel improvements and levees, land treatment practices, and nonstructural measures would be provided. Damages prevented would total about $1.3 million and damages remaining would amount to about $3.1 million annually.

LITTLE COLORADO PROGRAM
1966-1980

Irrigation and Drainage

The rehabilitation of irrigation facilities serving 6,000 acres of land to utilize more efficiently the present water supply and new irrigation water conveyance systems to serve 6,000 acres of land is included in the early action program. Additional storage facilities on Black Creek and the Zuni River in New Mexico are included to replace reservoir capacity lost through sedimentation and to provide water for a small increase in irrigation on Indian reservations. Onfarm irrigation water management measures are included to treat 10,000 acres of cropland during the period. No drainage is programed for the early action period. The irrigation program will cost $4.0 million.

Municipal and Industrial Water Supply

The Little Colorado Subregion is rural in character and contains only three medium-sized urban areas.

Municipal water requirements through 1980 could be supplied through continued development of local ground water, desalting of brackish water, and rehabilitation of some existing facilities. Estimated cost of the early action program is $11.0 million.

Recreation

Recreational development for this program would consist primarily of land-based facilities. Indian lands offer some of the best potentials for providing recreational development which, in turn, would improve the economic situation on the reservations.

The recreation needs for the Little Colorado Subregion to year 1980 will require the expenditure of $94 million for acquisition and development of 14,000 acres to satisfy the demand for 23 million recreation days. The framework plan will accomplish development and land acquisition to meet 5.7 million recreation days of use at a cost of $23.6 million.

Fish and Wildlife

The state fish and game departments and Federal land managing agencies have plans to develop habitat providing 250,000 man-days of fishing annually. In addition, the early action program includes habitat providing 29,000 man-days of fishing annually. The habitat and associated access and public-use facilities will be located in the vicinity of Flagstaff and Springerville, Arizona, and Gallup, New Mexico.

The 1966 to 1980 wildlife program includes accelerating development and increasing wildlife production on public lands; and intensively managing 31,500 acres of selected public lands to yield maximum fish and wildlife values with appropriate consideration of compatible and/or

complementary uses. Also, the early action program provides for the development of access roads, and 500 wildlife watering facilities.

The estimated cost of the early action fish and wildlife program is $5.4 million.

Electric Power

Construction of power plants have not been included in the early action program for this Subregion.

Continuing Program, 1981 - 2020

Multipurpose Water Supply

Approximately 17,000 acre-feet of water could be made available annually for municipal and industrial use in the Flagstaff, Winslow, and Holbrook areas by providing reservoir storage capacity of 40,000 acre-feet on Clear Creek. Fish and wildlife enhancement and recreation opportunities also would be provided.

Additional storage capacity of 40,000 acre-feet on Silver Creek could provide an average of 5,200 acre-feet of water for supplemental irrigation and municipal and industrial use. Fish and wildlife enhancement, recreation opportunities, and minor flood protection would also be provided.

Reservoir storage of 40,000 acre-feet on the Black River, a tributary of the Salt River, could provide water for a transbasin diversion of 7,800 acre-feet from the Gila Subregion for municipal and industrial uses and to alleviate irrigation water deficiencies in the vicinity of Springerville and St. Johns, Arizona. These facilities also could provide additional water for use on the Fort Apache Indian Reservation and for stabilizing major recreational lakes in the Little Colorado Subregion. An exchange of water would be required.

Further ground-water development is a potential alternative to surface-water storage, but further studies are needed before a quantitative evaluation can be made.

An additional 296,000 acres would be treated during the period to increase water yield by about 21,000 acre-feet annually. This program would assist in meeting some of the upstream water needs.

Water Quality

Waste water treatment facilities for the urban centers to reduce pollution of water supplies are included in the program.

LITTLE COLORADO PROGRAM
1981-2020

Land Treatment and Management

Increased pressure on land resources inherent in the Subregion's growing population will require a continuation of early action land treatment and management practices on an additional 10.6 million acres by 2020. Estimated cost of the 1981 to 2020 land treatment and management program for the Little Colorado Subregion is $184.8 million.

Flood Control

The flood control program includes upstream impoundments having capacity of about 71,000 acre-feet. In addition, 56 miles of channel improvements and levees, land treatment practices, and nonstructural measures would be provided. The program would prevent flood damage so that the remaining damages would amount to about $5.7 million annually.

Irrigation and Drainage

Irrigation acreage is expected to remain nearly constant. New conveyance systems would serve 4,000 acres and additional drainage facilities would serve 2,000 acres. Water management measures for better control and more efficient use of irrigation water are recommended for installation on 26,000 acres during the 1981 to 2020 period. Total cost of the irrigation program for this period is $3.6 million.

Municipal and Industrial Water Supply

Water supply developments contained in the programs are primarily to supply the municipal water supply requirements of Flagstaff, Winslow, and Holbrook, Arizona, and Gallup, New Mexico. Multipurpose reservoir storage on Clear Creek could provide about 17,000 acre-feet of water for use in Flagstaff, Winslow, and Holbrook, in the 2000 to 2020 time frame. Further studies are needed to evaluate the potential of ground water as an alternative. To meet the municipal water needs of Gallup, New Mexico, an importation of 7,500 acre-feet from the Upper Colorado Region is included in the 1980 to 2000 time frame, and, in the later stages of the period, a desalting plant to treat brackish ground water is provided. Small desalting plants for some of the scattered communities could assist in satisfying some of the rural water requirements where water is now transported from other areas due to the quality of the local ground water. Estimated total cost of the municipal and industrial water supply program for the 1981 to 2020 period in the Little Colorado Subregion is $57.0 million.

Recreation

Land acquisition totaling 16,000 acres would be required to satisfy the demand for 27 million recreation days of use. Development on Federal lands would satisfy 22 million recreation days. Deficits in water area

for recreation use would leave an unmet demand in the amount of 12 million recreation days. Estimated cost of acquisition and development to satisfy the demand during this period is $196 million. Under the framework plan approximately 31 million recreation days will be satisfied at a cost of $118 million.

Fish and Wildlife

Two multiple-purpose developments including Wilkin's Project on Clear Creek and Shumway Project on Silver Creek have been programed and these projects have the potential to provide 90,000 man-days of fishing annually. Also, the 1981 to 2020 program includes the development of small fishing lakes mainly in the vicinity of Flagstaff and Springerville, Arizona, and Gallup, New Mexico. The lakes total 2,000 acres and will provide 477,000 man-days of fishing annually. Two fish hatcheries have been programed in addition to fishermen access and other public-use facilities.

The continuing wildlife program for the Little Colorado Subregion identifies 434,000 acres of public lands as needing more intensive management to yield maximum wildlife values. The areas would be managed with emphasis directed to the production of fish and wildlife, with appropriate consideration of compatible and/or complementary uses. Also provided in the program is accelerated development and improved wildlife production on other public lands having wildlife values. The development of access roads and about 2,800 wildlife watering facilities are included in the program. Estimated cost of the continuing (1981 to 2020) fish and wildlife program is $20.1 million.

Electric Power

Fossil-fuel power plants having a total generating capacity of 100 megawatts and an annual energy production of 84,000 megawatt hours are included in the 1981 through 2020 program. The estimated cost of power plants and transmission systems is $60.0 million.

The following pages, XVIII-   through XVIII-   are summaries of the Little Colorado Subregion framework program in terms of facilities required, program accomplishments, installation costs, and operation, maintenance and replacement costs for the period 1966 to 2020.

Table F-10
LITTLE COLORADO SUBREGION
PROGRAM FACILITIES
AND RESOURCE IMPROVEMENT

PROGRAM FUNCTION	UNITS	1966-1980 PROGRAM	1981-2000 PROGRAM	2001-2020 PROGRAM
MULTIPURPOSE WATER SUPPLY				
Conservation Storage	1,000 A.F.	0	71.6	0
Recreation (Joint Use)	1,000 Ac.	0	1.2	0
Fish & Wildlife (Joint Use)	1,000 Ac.	0	1.2	0
Water Yield Improvement	1,000 Ac.	65	125	171
WATER QUALITY CONTROL				
Waste Water Treatment	mgd	6	12	18
LAND TREATMENT & MANAGEMENT	1,000 Ac.	4,044	6,033	4,609
Cropland (Acres Treated)	1,000 Ac.	(3)	(3)	(4)
Rangeland (Acres Treated)	1,000 Ac.	(3,092)	(4,506)	(3,977)
Forest Land (Acres Treated)	1,000 Ac.	(930)	(1,500)	(600)
Urban & Other (Acres Treated)	1,000 Ac.	(19)	(24)	(28)
FLOOD CONTROL				
Levees & Channels	miles	51	31	25
Reservoir & Detention Storage	1,000 A.F.	109	45	26
Land Treatment	1,000 Ac.	10	29	31
MUNICIPAL & INDUSTRIAL WATER				
Municipal Desalting Plants	mgd	3.0	8.0	4.0
RECREATION				
Land Acquisition	1,000 Ac.	2.8	0.4	2.9
Federal Acreage Shift	1,000 Ac.	381.7	292.5	220.7
FISH AND WILDLIFE				
Wildlife Facilities	No.	500	1,200	1,600
Fish Habitat	1,000 Ac.	0.1	0.4	1.6
Hatcheries	No.	0	1	1
ELECTRIC POWER				
Pumped Storage	GW	0	0	0
Fossil-fuel Thermal	GW	0	0	0.1
Nuclear Thermal	GW	0	0	0

Table F-11 - Little Colorado Subregion
PROGRAM ACCOMPLISHMENTS (Addition to 1965 Base)

PROGRAM FUNCTION	UNITS	1966-1980 PROGRAM	1981-2000 PROGRAM	2001-2020 PROGRAM
MULTIPURPOSE WATER SUPPLY				
Importations	1,000 AF/Yr	0	0	0
Surface Water Developments	1,000 AF/Yr	0	22	0
Water Salvage	1,000 AF/Yr	0	0	0
Water Yield Improvement	1,000 AF/Yr	5	8	13
WATER QUALITY CONTROL				
Waste Water Treatment	mgd	6	12	18
LAND TREATMENT & MANAGEMENT				
Value Crop Production	$ million/yr	3	4	6
Erosion Damage Prevention	$1,000/yr	300	1,100	1,900
Wildfire Damage Prevention	$1,000/yr	--	--	--
Increased Grazing Capacity	1,000 AUM/yr	55	228	333
Increased Timber Harvest	Mil. CF/Yr	12	35	42
Decreased Sediment Yield	AF/Yr	751	2,220	3,511
FLOOD CONTROL - DAMAGE PREVENTION	$1,000/yr	1,280	4,530	11,370
IRRIGATION				
New Distribution System	1,000 Ac.	6	3	1
Rehabilitation of Distribution System	1,000 Ac.	6	0	0
Land Preparation, Onfarm Facilities	1,000 Ac.	10	13	13
DRAINAGE	1,000 Ac.	0	1	1
MUNICIPAL & INDUSTRIAL WATER				
Desalting Brackish Water	mgd	3.0	8.0	4.0
RECREATION	million recreation days/yr	5.7	20.0	11.1
FISH & WILDLIFE				
Fishing	1,000 man-days/yr	279	199	368
Hunting	1,000 man-days/yr	15	47	92
ELECTRIC POWER				
Capacity	GW	0	0	0.1
Energy	gwh/yr	0	0	84

Table F-12
LITTLE COLORADO SUBREGION
INSTALLATION COSTS
(Increments in each time frame in millions of dollars)

PROGRAM FUNCTION	1966-1980 PROGRAM		1981-2000 PROGRAM		2001-2020 PROGRAM	
	Federal	Non-Federal	Federal	Non-Federal	Federal	Non-Federal
WATER SUPPLY--MULTIPURPOSE	4.6	1.0	25.1	2.0	9.0	1.0
Surface Water Development	(0)	(0)	(16.6)	(0)	(0)	(0)
Water Yield Improvement	(4.6)	(1.0)	(8.5)	(2.0)	(9.0)	(1.0)
WATER QUALITY CONTROL	2	2	2	2	1	3
Waste Water Treatment	(2)	(2)	(2)	(2)	(1)	(3)
LAND TREATMENT AND MANAGEMENT	50.9	10.2	112.4	17.7	57.3	17.1
Cropland						
Erosion, Sediment and Runoff Control	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)
Soil Survey	(0)	(0)	(0)	(0)	(0)	(0)
Rangeland						
Erosion, Sediment and Runoff Control	(4.5)	(2.5)	(5.9)	(3.5)	(3.4)	(2.8)
Forage Production	(1.5)	(0.9)	(2.3)	(1.2)	(1.1)	(1.3)
Wildfire, Prevention and Suppression	(-)	(-)	(-)	(-)	(-)	(-)
Forest Land						
Erosion, Sediment and Runoff Control	(27.9)	(4.7)	(58.8)	(6.3)	(25.5)	(9.7)
Timber Production	(11.0)	(0.9)	(31.4)	(3.1)	(11.5)	(2.0)
Forage Production	(1.1)	(0.1)	(5.2)	(0.5)	(6.4)	(0.2)
Wildfire, Prevention and Suppression	(0.2)	(-)	(0.2)	(-)	(0.3)	(-)
Urban						
Erosion, Sediment and Runoff Control	(4.6)	(1.0)	(8.5)	(2.0)	(9.0)	(1.0)
FLOOD CONTROL	21.4	1.8	12.7	2.5	8.9	4.2
Levees and Channels	(3.9)	(0.3)	(4.9)	(0.8)	(3.1)	(0.3)
Reservoirs	(17.1)	(0.2)	(6.1)	(0.1)	(4.7)	(0.1)
Flood Plain Regulation	(0.1)	(1.2)	(0.1)	(1.2)	(0.1)	(2.2)
Land Treatment	(0.3)	(0.1)	(1.6)	(0.4)	(1.0)	(1.6)
IRRIGATION	2.2	1.8	1.2	1.1	0.2	1.1
Irrigation Development	(1)	(1)	(1)	(0)	(0)	(0)
Rehabilitation of Distribution Systems	(1)	(0)	(0)	(0)	(0)	(0)
Land Preparation, Onfarm Facilities	(0.2)	(0.8)	(0.2)	(1.1)	(0.2)	(1.1)
DRAINAGE	0	0	1	0	0	0
MUNICIPAL AND INDUSTRIAL WATER	0	11	36	15	0	6
Desalting Brackish Water	(0)	(2)	(0)	(7)	(0)	(1)
Other Water Development	(0)	(9)	(36)	(8)	(0)	(5)
RECREATION	6.0	17.6	73.4	3.3	25.4	18.3
Land Acquisition and Development	(6.0)	(17.6)	(71.3)	(3.3)	(25.4)	(18.3)
Reservoirs (Joint Use)	(-)	(-)	(2.1)	(-)	(-)	(-)
FISH AND WILDLIFE	3.7	1.7	5.7	1.6	9.6	3.2
Fish	(1.7)	(0.7)	(1.7)	(0.6)	(4.5)	(1.5)
Wildlife	(2.0)	(1.0)	(3.1)	(1.0)	(5.1)	(1.7)
Multipurpose Reservoirs	(0)	(0)	(0.9)	(0)	(0)	(0)
ELECTRIC POWER						10
Power Plants	(0)	(0)	(0)	(0)	(0)	(10)

Table F-13
LITTLE COLORADO SUBREGION
ANNUAL OPERATION, MAINTENANCE AND REPLACEMENT COSTS
(Cumulated above 1965 level at last year of time frame in thousands of dollars)

PROGRAM FUNCTION	1966-1980 PROGRAM		1981-2000 PROGRAM		2001-2020 PROGRAM	
	Federal	Non-Federal	Federal	Non-Federal	Federal	Non-Federal
WATER SUPPLY--MULTIPURPOSE	525	25	5,400	2,065	8,400	1,565
Surface Water Development	(-)	(-)	(-)	(15)	(-)	(15)
Water Yield Improvement	(525)	(25)	(5,400)	(2,050)	(8,400)	(1,550)
WATER QUALITY CONTROL	22	197	34	324	34	390
Waste Water Treatment	(22)	(197)	(34)	(324)	(34)	(390)
LAND TREATMENT AND MANAGEMENT	4,287	1,311	7,678	3,422	10,656	2,176
Cropland						
Erosion, Sediment and Runoff Control	(3)	(9)	(4)	(10)	(4)	(10)
Soil Survey	(-)	(-)	(-)	(-)	(-)	(-)
Rangeland						
Erosion, Sediment and Runoff Control	(310)	(110)	(435)	(130)	(468)	(137)
Forage Production	(181)	(52)	(259)	(62)	(259)	(54)
Wildfire, Prevention and Suppression	(33)	(2)	(48)	(5)	(55)	(7)
Forest Land						
Erosion, Sediment and Runoff Control	(2,617)	(932)	(4,511)	(2,770)	(6,781)	(1,407)
Timber Production	(300)	(5)	(880)	(30)	(765)	(5)
Forage Production	(35)	(20)	(225)	(75)	(550)	(65)
Wildfire, Prevention and Suppression	(800)	(105)	(1,300)	(200)	(1,750)	(275)
Urban						
Erosion, Sediment and Runoff Control	(8)	(76)	(16)	(140)	(24)	(216)
FLOOD CONTROL	48	43	39	76	104	69
Levees & Channels	(0)	(20)	(0)	(32)	(0)	(29)
Reservoirs	(0)	(7)	(0)	(25)	(0)	(20)
Flood Plain Regulation	(30)	(7)	(20)	(7)	(0)	(10)
Land Treatment	(18)	(9)	(19)	(12)	(104)	(10)
IRRIGATION AND DRAINAGE	7	388	7	403	7	403
Irrigation Development	(-)	(220)	(-)	(228)	(-)	(228)
Drainage Development	(-)	(-)	(-)	(7)	(-)	(7)
Land Preparation, Onfarm Facilities	(7)	(168)	(7)	(168)	(7)	(168)
MUNICIPAL AND INDUSTRIAL WATER	-	380	-	980	-	1,130
RECREATION	500	1,500	6,300	1,900	8,300	3,900
FISH AND WILDLIFE	300	100	645	185	838	280
Fish	(75)	(25)	(225)	(75)	(313)	(105)
Wildlife	(225)	(75)	(375)	(125)	(525)	(175)
Multipurpose Reservoirs	(0)	(0)	(45)	(0)	(0)	(0)
ELECTRIC POWER						
Power Plants	(-)	(-) 1/	(-)	(-) 1/	(-)	1,500

1/ The annual power plant OM&R was estimated to be less than the 1965 level in the years 1980 and 2000.

GILA SUBREGION

PROGRAM SUMMARY

A framework program developed to sustain a growing economy in the Gila Subregion is summarized in tables at the end of this chapter.

Early Action Program, 1966 - 1980

Multipurpose Water Supply

The early action program proposes the authorized Central Arizona Project for construction during the 1966 to 1980 time frame. As planned, the project will convey annually 1.67 million acre-feet of the State of Arizona's Colorado River water entitlement to the water deficient areas. The project is designed to provide a supplemental water supply to 1.2 million acres of irrigated lands and 312,000 acre-feet of water for municipal and industrial use in the Phoenix and Tucson areas. Central Arizona Project storage facilities of about 2.1 million acre-feet capacity also will provide: regulation of water imported from the Colorado River; regulation of Gila and San Pedro River flows; flood and sediment control; fish and wildlife enhancement and outdoor recreation opportunities. Additional regulation of flows for irrigation, mining, and municipal uses in the upper reaches of the Gila River in New Mexico will be provided by construction of Hooker Reservoir or suitable alternate. Exchange water will be provided through the Central Arizona Project to replace the additional water used to satisfy downstream water rights. Regulation of flows in the middle reaches of the Gila River immediately below the inflow of the San Pedro River will be provided through construction of a reservoir having a capacity of about 366,000 acre-feet. The major function of this reservoir will be to regulate and impound floodflows from the San Pedro River to provide flood protection and maximize utilization of such floodflows for beneficial uses. Reservoir storage of about 238,000 acre-feet will be provided in the upper reaches of the San Pedro River to supply about 12,000 acre-feet of water for municipal use in Tucson, Arizona, and to provide flood prevention, recreation opportunities, and fishery enhancement. Reservoir storage of about 1.36 million acre-feet will be constructed immediately downstream from the confluence of the Salt and Verde Rivers north of Phoenix. This reservoir will provide terminal storage for the aqueduct from the Colorado River, will regulate for beneficial use the floodflow now occasionally escaping the present Salt and Verde River reservoir systems, will provide flood protection for the

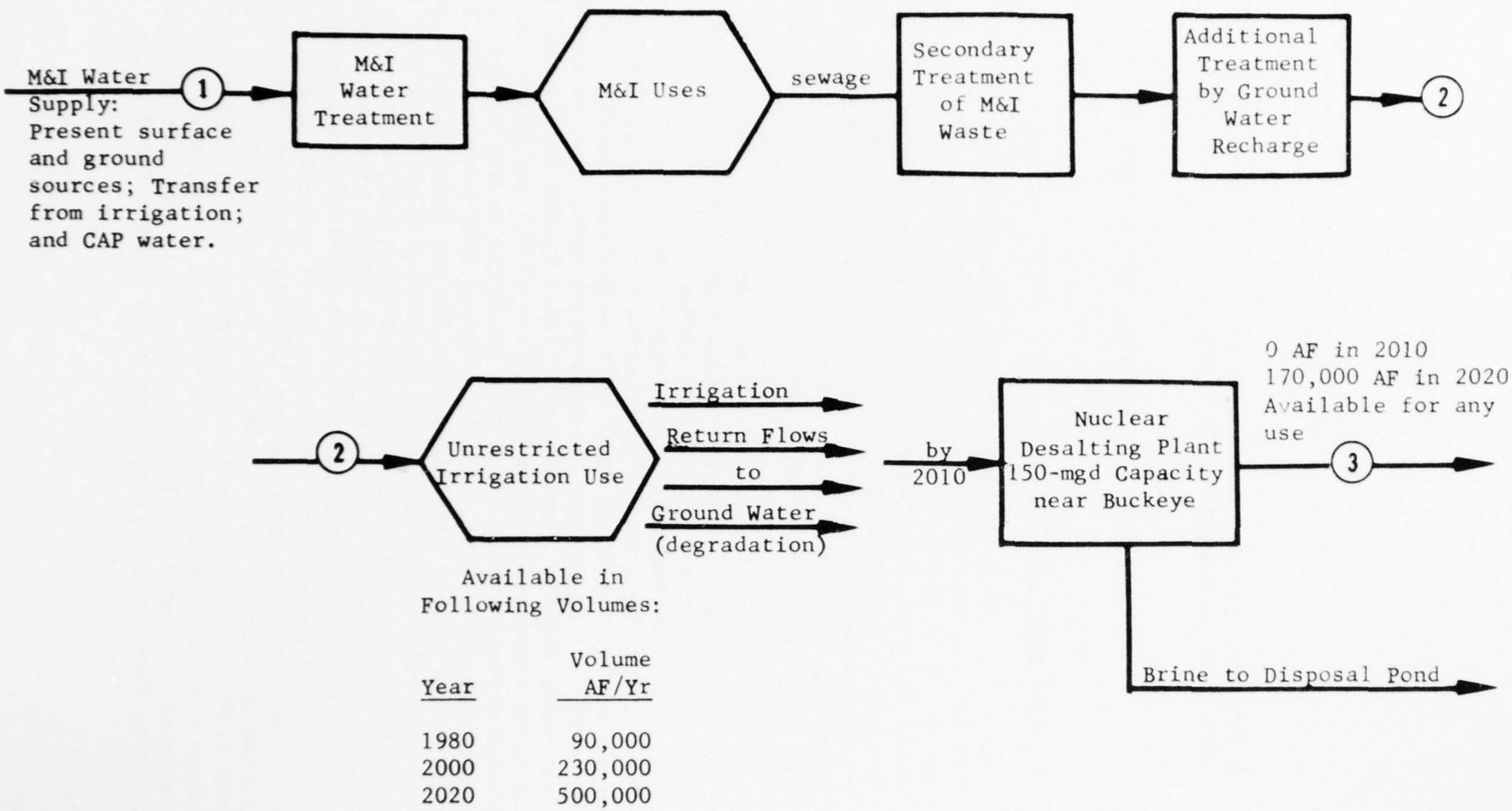


Figure F-2-Schematic Diagram of Program for Water Use and Reuse in Maricopa County, Arizona

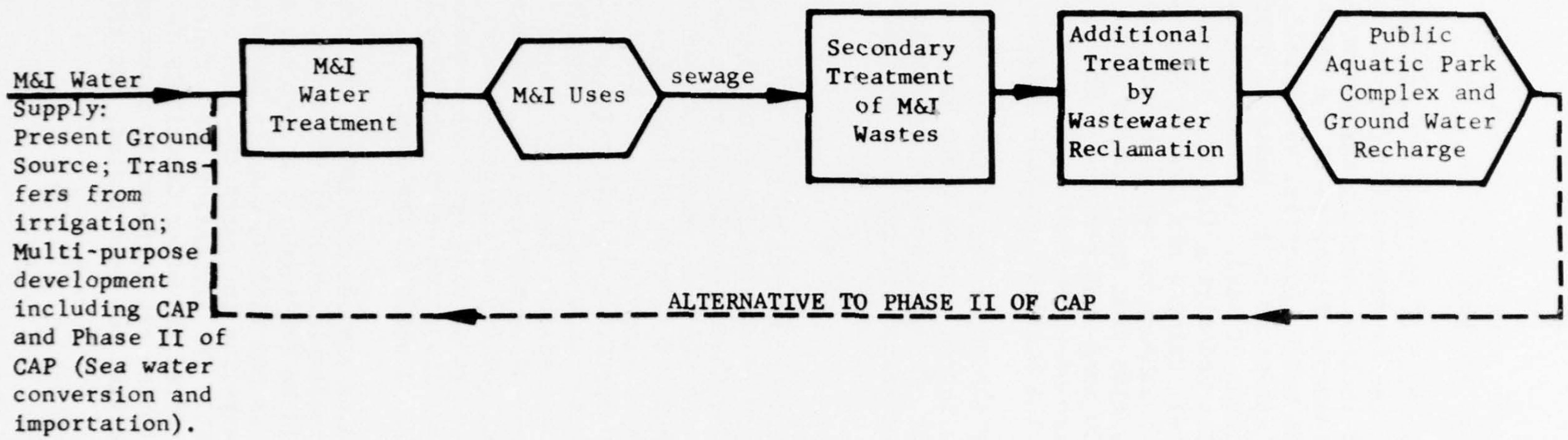


Figure F-3-Schematic Diagram of Program for Water Use and Reuse in Pima County, Arizona

urban area of Phoenix, and will make available considerable water-based recreation and fishing opportunities.

Further evaluation of the potential of ground-water basins outside critical areas of use is recommended for the continuing investigation. Evaluation should include locating any presently untapped ground-water basins within reasonable distances of the demand centers; determination of depth to ground water, potential well yield, and volume of water in storage; and estimates of the costs of extracting ground water and conveying it to areas of need. A promising possibility appears to be ground-water basins underlying the high mountain regions, above 6,000 feet, of the Plateau Uplands and Central Highlands Provinces in north-central Arizona. Although no reliable estimates can be made at this time, sustained yields from these basins could be in the order of 100,000 to 500,000 acre-feet per year. Should studies of these or other potential ground-water basins indicate feasibility, it is recommended that the earliest possible utilization be accomplished.

Treatment of 140,000 acres of forest land is provided in the early action program to increase water yield by about 80,000 acre-feet. This includes treatment of 30,000 acres of riparian vegetation and 110,000 acres of upland watersheds during this period.

Water Quality

The water quality control program in the Gila Subregion is based on developing major reuse facilities for Maricopa and Pima Counties, and the program for these counties is shown on the following schematic diagrams. Under the plan all wastes are treated to an equivalent secondary level and the treated effluent applied to the land to effect additional removal of impurities by infiltration through the soil. A pilot project now operating on this principle is experiencing encouraging results. Water made available by ground-water recharge from this operation would be available for unrestricted irrigation use in quantities shown on the schematic diagrams. Irrigation drainage would further lessen the quality of the ground water in the area. Effluent from the irrigation reuse will approach a quality of approximately 4,000 mg/l of total dissolved solids which would cause continued deterioration of the ground water in the area.

Further studies are recommended of the treatment and recycling of waste flows, the potential uses of the water, and the water distribution systems that would be required. The high degree of water utilization in the Subregion is not without penalty because, unless treatment is provided, each recycling increases the salt content until the water becomes unacceptable for irrigation use. Since surface outflow from the Subregion is rare, the major depository for the salts is the ground-water basins. Studies are proposed to determine the rate of ground-water degradation that may be expected, the effects thereof, and the

alternative solutions for alleviation of the problem. Possible alternatives could include desalting of ground water prior to its use, and the desalting and direct reuse of return flows where significant quantities occur. Obtaining salt balance in the basin by providing water for outflow from the Subregion probably could be considered only when adequate quantities of imported water become available. Figure F-2 and Figure F-3 are schematic diagrams of how water might be used, reclaimed, and reused in Maricopa and Pima Counties, respectively.

Land Treatment and Management

The program includes treatment of 7.5 million acres by 1980 at a total cost of $110.2 million. Of the total program, 3 percent of the cost will be on cropland, 47 percent on rangeland, 47 percent on forest land, and 3 percent on urban and other lands. Measures for erosion, sediment, and runoff control will be provided on 116,000 acres of cropland during the period. About 5.3 million acres of rangeland; 2.0 million acres of forest land; and 107,000 acres of urban and other lands will be adequately treated during this period. The recommended land treatment and management program by land resource group is previously explained.

Flood Control

Increased growth in the Gila Subregion will require additional flood control facilities. Included in the early action program is flood control storage as follows: 1.27 million acre-feet would be provided by multipurpose reservoirs authorized as a part of the Central Arizona Project; an additional 0.29 million acre-feet would be in downstream flood detention facilities; and .42 million acre-feet would be in upstream facilities. In addition, 431 miles of flood channel improvement and 92 miles of levees, land treatment practices, and nonstructural measures will be provided. Damages prevented would total about $22.1 million and remaining damages would amount to about $25.9 million annually.

Irrigation and Drainage

The ongoing program to rehabilitate existing irrigation water conveyance systems serving 320,000 acres of irrigated land is expected to be completed by 1980. New conveyance facilities to serve 213,000 acres of land also are included in the early action program. New facilities would provide for coordinated ground-surface water utilization and some additional irrigation on Indian lands.

Water management control measures are included on 435,000 acres of irrigated land for the more efficient use of irrigation water and to reduce costs of irrigation. It is recommended that studies include possible means of reducing nonbeneficial consumptive uses associated with irrigation.

It is expected that about 26,000 acres of irrigated land will be converted to urban uses during the 1965 to 1980 period. Harvested acreage, however, is expected to increase by about 151,000 acres. Additional irrigation development is expected to total about 127,000 acres. The remaining 24,000 acre increase in harvested area is expected to result from decreased crop failures and decreases in the acreage of developed land remaining idle because of insufficient water supplies. Some of the additional irrigation would be on Indian reservation lands. Drainage facilities would be provided to serve an additional 1,000 acres. The irrigation and drainage program for the Gila Subregion to 1980 will cost $162.3 million.

Municipal and Industrial Water Supply

More than 80 percent of the municipal and industrial water demands of the Gila Subregion are found in the Maricopa and Pima Counties of Arizona where Phoenix and Tucson are located. Withdrawal of water for municipal and industrial uses is expected to increase by about 200,000 acre-feet from 1965 to 1980. Completion of the Central Arizona Project by the end of the time period would provide about 312,000 acre-feet for municipal and industrial use. Some additional water will also be made available by the continuing conversion of irrigated lands to urban use. Existing surface and ground-water supplies will continue to be utilized.

Numerous small demand centers scattered throughout the remainder of the Subregion are expected to continue to supply their water needs by further development of present sources. The Central Arizona Project will make possible water exchanges, allowing local development of tributaries for municipal use. The needs of five small communities would be satisfied by desalting brackish ground water.

Total estimated cost of the early action municipal and industrial water supply program for the Gila Subregion is $22.0 million.

Recreation

Recreation needs in the Gila Subregion are expected to continue to be concentrated in the Phoenix-Tucson areas. Water-based recreation needs can be partially met by facility development at existing lakes and reservoirs. New water project construction, such as the Central Arizona Project, would provide about 16,000 water surface acres of recreation opportunity to augment existing water surface acreages. Since water surface needs for recreation do appear in future time frames, attention should be given to possible transfers of recreation opportunities from existing waters to new water surface particularly if new projects are located nearer urban centers.

The urban recreational development program includes canal-side parks, perimeter riding and hiking trails, and other park development.

A number of areas in the Subregion are recommended for consideration for preservation as historic, scenic, or natural areas.

The receational needs for the Gila Subregion to year 1980 will require the expenditure of $299 million for the acquisition and development of 30,000 acres of land to satisfy the need for 78 million recreation days. Under the framework plan only 30 million recreation days will be satisfied at a cost of $114 million.

Fish and Wildlife

The early action wildlife program for the Gila Subregion includes accelerating development and increasing wildlife production on public lands and the identification of approximately 154,000 acres of high value riparian habitat to yield maximum wildlife production and values with appropriate consideration of compatible and/or complementary uses. The identified areas are mostly located near population centers and are possibly the most important in the Region in relation to production of upland and nongame wildlife species. Also, the early action program provides for the construction of access roads.

Total estimated cost of the early action fish and wildlife program for the Gila Subregion is $26.4 million.

Electric Power

Electric power demands in the Subregion will be supplied partially from other areas. The availability of water near cheap fuel sources makes it more economical to transmit electric energy long distances to load centers than to use high cost fuels near the load center for base load power plant operation. However, the rapidly increasing demands for electricity also will require peaking power plants within the Subregion. Because of water deficiency, only pumped storage power facilities having installed capacity of 750,000 kilowatts are included in the early action program. Estimated cost of the power plants and transmission systems is $471 million.

A small amount of conventional hydroelectric potential has been reported, by the Federal Power Commission, to exist in this Subregion. This potential has not been included in the program because no detailed investigation of the sites has been made.

Continuing Program, 1981 - 2020

Multipurpose Water Supply

With the annual transfer of 1.67 million acre-feet of Colorado River water to the Gila Subregion in 1980, as provided by the Central

Arizona Project, the water deficiency remaining is projected to be 1.4 million acre-feet annually. Even after all contemplated means of conservation and augmentation within the Region are in operation, the net water deficiency would increase to about 2.3 million acre-feet by year 2000 and to 3.6 million acre-feet by year 2020. It is expected that importation of water from outside the Region could not begin until 1990 or 1995. The interim result will be continued ground-water overdraft accompanied by degradation of ground-water quality, greater pumping lifts, and additional land subsidence. Water uses will need to be weighed carefully and some needs necessarily may remain unsatisfied until an adequate supply of import water becomes available.

Additional water, totaling about 128,000 acre-feet annually, would be made available through increased watershed yields obtained by vegetative management on 604,000 acres. Most of this work would involve modifying timber harvesting practices and by conversion of chaparral and mountain brush to shallow-rooted grasses and forbs on watershed lands at higher elevations where precipitation is higher.

The most critical continuing program is water importations into the Gila Subregion to alleviate the ground-water overdraft and to satisfy increasing water requirements. Total augmentation required in year 2000 would be about 3.1 million acre-feet, of which about 1.1 million acre-feet would be supplied from the Colorado River and 2.0 million acre-feet would be imported from outside the Region. By year 2020, the total augmentation program would increase to 4.0 million acre-feet, of which 0.8 million acre-feet would be from the Colorado River and 3.2 million acre-feet would be imported from outside the Region. Additional conveyance facilities would be constructed in each of the time frames of 1980 to 2000 and 2000 to 2020 to convey the water to the areas of need. The location of such facilities would be governed by future growth patterns in the Subregion. The possibility of locating future facilities to encourage population dispersement should be considered.

Importation of water to downstream areas would make possible upstream development through the water exchanges. A major development of this type would be construction of about 700,000 acre-feet of storage facilities on the Gila River above Coolidge Dam which could provide a regulated water supply for 54,000 acres of presently irrigated lands; for the development of mineral resources; for municipal and industrial purposes; for water-based recreation opportunities; and for fishing enhancement.

Importation facilities would include terminal storage reservoirs totaling about 600,000 acre-feet of capacity. The storage would need to be located in the vicinity of major urban centers and could be utilized to satisfy a large part of the water-based recreation and fishery needs.

Water Quality

Degradation of ground-water quality will continue to increase as water use increases if outflow from the Subregion is not provided. The program includes a desalting plant in the Buckeye area, where important quantities of saline drainage water are expected to accumulate. The desalted water would be returned for use.

Other considerations could include providing a salt balance either by adding water to provide outflow from the Subregion or by allowing the ground water to degrade in quality, necessitating treatment of withdrawals prior to use. Studies were recommended in the early action program to define further the water quality problems and to determine alternative means for their solution.

Land Treatment and Management

Increased pressure on land resources inherent in the Subregion's growing population will require a continuation of early action land treatment and management practices on an additional 18.7 million acres by 2020 at a total cost in excess of $304.1 million.

The program includes treatment of 303,000 acres of cropland; 14.1 million acres of rangeland; about 4.0 million acres of forest land; and 290,000 acres of urban and other land.

Flood Control

The continuing program for flood control provides 980,000 acre-feet of reservoir capacity, of which about 40 percent would be upstream facilities. In addition, 531 miles of flood channel improvements and levees, land treatment practices, and nonstructural measures would be provided. The program would reduce annual flood damages by $36 million so that the remaining damages would amount to about $42.7 million.

Irrigation and Drainage

During the period of 1980 to 2020, it is estimated that nearly 167,000 acres of irrigated lands will be lost to urbanization while a net gain of about 80,000 harvested acreage is expected. This would require additional irrigation development to serve 247,000 acres. This increase in harvested acres is expected to be largely the result of private development in outlying ground-water basins and development on Indian lands. The continuing program includes coordinating of the use of the ground-surface water supply by providing additional conveyance facilities for irrigation of 426,000 acres. Water management measures to provide better control and more efficient use of irrigation water are recommended for installation on 1.1 million acres during the 1980-2020 period.

Additional drainage facilities would be provided to serve 62,000 acres. An annual accumulation of about 300,000 acre-feet of drainage water is expected to occur in the Buckeye area. Facilities for treatment and reuse of this water are contained in the water quality program.

Total cost of the continuing irrigation and drainage program (1981 to 2020) is estimated at $369.2 million.

Municipal and Industrial Water Supply

Municipal and industrial water requirements would be supplied largely from present surface- and ground-water sources, by Colorado River water imported through the Central Arizona Project facilities, and by subsequent importation of water from outside the Region. Conversion of irrigated lands to urban uses probably will result in some water being transferred from agricultural to municipal uses. The program also includes enlargement of five small desalting plants for cities that appear to be too far from the area served by the Central Arizona Project.

The importation of water to the downstream areas also will permit small communities along the tributaries to develop local surface-water supplies under the exchange principle.

It is recommended that detailed studies be initiated to determine needs of the many small communities and to evaluate the local surface- and ground-water resources available to meet these needs. Studies for defining the need for exchange water through importation facilities are also recommended.

Estimated cost of the continuing (1981 to 2020) municipal and industrial water supply program for the Gila Subregion is $116.0 million.

Recreation

The 1981 to 2020 recreation program for the Gila Subregion includes continued development of urban-oriented facilities such as parks, riding and hiking trails, etc., and rural-oriented recreation needs would be supplied by preservation of land through acquisition, construction of recreational facilities, and provision of access facilities. Reservoirs constructed during the first time frame would be needed during the remaining time period to satisfy water-based recreation needs. A deficit of 47,000 water surface acres to meet recreation needs will exist by 2020.

The recreation needs would require acquisition and development of 130,000 acres of land to supply 303 million recreation days at a total estimated cost of $1.1 billion. Under the framework plan only 133 million recreation days will be met at a cost of $507 million.

Fish and Wildlife

Multiple-purpose projects planned for the period 1981 to 2020 are the Upper Gila River Project, Reserve, and Alma Reservoirs on the San Francisco River, and the importation programs, collectively, are expected to add habitat capable of providing 930,000 man-days of fishing annually. Regulating reservoirs for import water would be provided within 75 miles of the large urban areas and the exchange water principle would provide opportunity for upstream development.

The 1981 to 2020 program also includes the development of 18,000 acres of small primary-purpose fishing lakes. The majority of this, 10,900 acres, is planned for the Phoenix-Tucson metropolitan areas and would provide 5.5 million man-days of fishing annually. The remaining 7,100 acres are programed to be developed as small cold water fishing lakes distributed in the high-demand areas of the Mogollon Rim and other areas of need. These lakes would provide an additional 1.5 million man-days of fishing annually.

In addition, the 1981 to 2020 program includes the development of 6 fish hatcheries, fishermen access, and other user facilities.

The continuing wildlife program for the Gila Subregion includes the intensive management of 1.7 million acres of mostly public lands to yield maximum fish and wildlife production and values with appropriate consideration of compatible and/or complementary uses. Also the program provides for accelerating development and improving wildlife production on other public lands having wildlife values. The development of approximately 150 miles of access roads and 32,000 wildlife watering stations are provided in the continuing program (1981 to 2020).

The estimated cost of the 1981 to 2020 fish and wildlife program for the Gila Subregion is $206.3 million.

Electric Power

Electric power requirements are projected to continue increasing at a rapid rate. Facilities to supply 88.1 gw of the Region's requirements for generating capacity are included in the program for the Subregion. Estimated cost of power plants and transmission systems is $17.7 billion.

Studies are proposed to consider the extent that water should be devoted to the production of thermal electric power in the Subregion, as well as possible alternatives to power plant locations or cooling methods to meet the projected high electric power requirements. Water for cooling would be recycled until depleted.

GILA PROGRAM
1981-2020

The following pages, XVIII-253 through XVIII-256 are summaries of the Gila Subregion framework program in terms of facilities required, program accomplishments, installation costs, and operation, maintenance, and replacement costs for the period 1965 to 2020.

Table F-14
GILA SUBREGION
PROGRAM FACILITIES
AND RESOURCE IMPROVEMENT

PROGRAM FUNCTION	UNITS	1966-1980 PROGRAM	1981-2000 PROGRAM	2001-2020 PROGRAM
MULTIPURPOSE WATER SUPPLY				
Conservation Storage	1,000 A.F.	570	769	200
Recreation (Joint Use)	1,000 Ac.	22.1	7.9	5.0
Fish & Wildlife (Joint Use)	1,000 Ac.	22.1	7.9	5.0
Conveyance System & over 100 cfs	miles	304	304	304
Water Yield Improvement	1,000 Ac.	110	400	204
WATER QUALITY CONTROL				
Conventional Waste Water Treatment	mgd	150	230	390
Tertiary Waste Water Treatment	mgd	210	250	360
Drainage Water Treatment	mgd	0	0	150
LAND TREATMENT & MANAGEMENT	1,000 Ac.	7,490	10,377	8,294
Cropland (Acres Treated)	1,000 Ac.	(116)	(154)	(149)
Rangeland (Acres Treated)	1,000 Ac.	(5,267)	(7,798)	(6,330)
Forest Land (Acres Treated)	1,000 Ac.	(2,000)	(2,300)	(1,650)
Urban & Other (Acres Treated)	1,000 Ac.	(107)	(125)	(165)
FLOOD CONTROL				
Levees & Channels	miles	523	323	209
Reservoir & Detention Storage	1,000 A.F.	1,979	404	576
Land Treatment	1,000 Ac.	155	220	203
MUNICIPAL & INDUSTRIAL WATER				
Municipal Desalting Plants	mgd	4.5	0	10.0
RECREATION				
Land Acquisition	1,000 Ac.	6.0	8.9	16.9
Federal Acreage Shift	1,000 Ac.	39.9	18.5	9.1
FISH & WILDLIFE				
Wildlife Facilities	No.	0	8,000	24,000
Fish Habitat	1,000 Ac.	0.1	3.6	14.4
Hatcheries	No.	4	3	3
ELECTRIC POWER				
Pumped Storage	GW	0.8	3.7	4.1
Fossil-fuel Thermal	GW	0	12.4	31.4
Nuclear Thermal	GW	0	5.0	31.5

Table F-15 - Gila Subregion
PROGRAM ACCOMPLISHMENTS (Addition to 1965 Base)

PROGRAM FUNCTION	UNITS	1966-1980 PROGRAM	1981-2000 PROGRAM	2001-2020 PROGRAM
MULTIPURPOSE WATER SUPPLY				
Importations	1,000 AF/Yr	0	1,930	1,320
Surface Water Development	1,000 AF/Yr	72	76	0
Water Salvage	1,000 AF/Yr	35	--	--
Intraregional Water Transfer	1,000 AF/Yr	1,670	0	0
Water Yield Improvement	1,000 AF/yr	25	80	48
WATER QUALITY CONTROL				
Conventional Waste Water Treatment	mgd	150	230	390
Tertiary Waste Water Treatment	mgd	210	250	360
Drainage Water Treatment	mgd	0	0	150
LAND TREATMENT & MANAGEMENT				
Value Crop Production	$ million/yr	357	504	657
Erosion Damage Prevention	$1,000/yr	1,500	5,800	11,000
Wildfire Damage Prevention	$1,000/yr	1,035	3,169	7,969
Increased Grazing Capacity	1,000 AUM/yr	161	744	1,291
Increased Timber Harvest	Mil. CF/Yr	9	4	4
Decreased Sediment Yield	AF/Yr	1,148	3,176	4,595
FLOOD CONTROL - DAMAGE PREVENTION	$1,000/yr	22,090	66,220	173,180
IRRIGATION				
New Distribution System	1,000 Ac.	213	576	97
Rehabilitation of Distribution System	1,000 Ac.	320	0	0
Land Preparation, Onfarm Facilities	1,000 Ac.	435	581	561
DRAINAGE	1,000 Ac.	1	13	49
MUNICIPAL & INDUSTRIAL WATER				
Desalting Brackish Water	mgd	4.5	0	10.0
RECREATION	million recreation days/yr	29.9	70.0	63.3
FISH & WILDLIFE				
Fishing	1,000 man-days/yr	2,540	2,388	5,590
Hunting	1,000 man-days/yr	0	355	1,089
ELECTRIC POWER				
Capacity	GW	0.8	21.1	67.0
Energy	gwh/yr	400	63,500	294,100

Table F-16
GILA SUBREGION
INSTALLATION COSTS
(Increments in each time frame in millions of dollars)

PROGRAM FUNCTION	1966-1980 PROGRAM		1981-2000 PROGRAM		2001-2020 PROGRAM	
	Federal	Non-Federal	Federal	Non-Federal	Federal	Non-Federal
WATER SUPPLY--MULTIPURPOSE	736.7		665.0	3.0	354.0	3.5
Intraregional Water Transfers	(729)	0	(592)	0	(338)	0
Surface Water Development	(0)	(0)	(60)	(0)	(0)	(0)
Water Yield Improvement	(7.7)	(3.0)	(13.0)	(3.0)	(16.0)	(3.5)
WATER QUALITY CONTROL	30	39	31	43	203	75
Conventional Waste Water Treatment	(29)	(38)	(30)	(42)	(42)	(74)
Tertiary Waste Water Treatment	(1)	(1)	(1)	(1)	(1)	(1)
Drainage Water Treatment	(0)	(0)	(0)	(0)	(160.0)	(0)
LAND TREATMENT AND MANAGEMENT	81.4	28.8	158.0	40.0	71.5	34.6
Cropland						
Erosion, Sediment and Runoff Control	(0.8)	(2.0)	(1.1)	(2.7)	(1.1)	(2.7)
Soil Survey	(0.3)	(-)	(0.4)	(-)	(0.4)	(-)
Rangeland						
Erosion, Sediment and Runoff Control	(31.0)	(10.9)	(38.5)	(15.6)	(17.7)	(11.3)
Forage Production	(5.9)	(3.5)	(8.5)	(4.0)	(4.5)	(4.9)
Wildfire, Prevention and Suppression	(-)	(-)	(-)	(-)	(-)	(-)
Forest Land						
Erosion, Sediment and Runoff Control	(32.8)	(8.3)	(83.7)	(10.6)	(39.5)	(11.2)
Timber Production	(9.0)	(1.3)	(16.4)	(3.1)	(1.0)	(0.1)
Forage Production	(0.8)	(0.2)	(8.4)	(1.0)	(5.9)	(0.4)
Wildfire, Prevention and Suppression	(0.2)	(-)	(0.2)	(-)	(0.4)	(-)
Urban						
Erosion, Sediment and Runoff Control	(0.6)	(2.6)	(0.8)	(3.0)	(1.0)	(4.0)
FLOOD CONTROL	229.0	31.6	211.4	47.1	166.6	46.7
Levees and Channels	(63.9)	(11.7)	(147.1)	(22.7)	(44.7)	(2.7)
Reservoirs	(161.7)	(7.3)	(60.3)	(4.6)	(118.5)	(16.1)
Flood Plain Regulation	(0.6)	(10.1)	(0.4)	(16.7)	(0.3)	(24.2)
Land Treatment	(2.8)	(2.5)	(3.6)	(3.1)	(3.1)	(3.7)
IRRIGATION	102.0	60.3	177.6	57.6	34.2	50.8
Irrigation Development	(46)	(20)	(167)	(11)	(24)	(6)
Rehabilitation of Distribution Systems	(48)	(5)	(0)	(0)	(0)	(0)
Land Preparation, Onfarm Facilities	(8.0)	(35.3)	(10.6)	(46.6)	(10.2)	(44.8)
DRAINAGE	1	0	10	1	37	1
MUNICIPAL AND INDUSTRIAL WATER	0	22	3	46	0	67
Desalting Brackish Water	(0)	(5)	(0)	(0)	(0)	(6)
Other Water Development	(0)	(17)	(3)	(46)	(0)	(61)
RECREATION	76.0	44.6	210.5	66.5	112.0	122.8
Land Acquisition and Development	(69.6)	(44.6)	(205.6)	(66.5)	(112.0)	(122.8)
Reservoirs (Joint Use)	(6.4)	(-)	(4.9)	(-)	(-)	(-)
FISH AND WILDLIFE	21.1	5.3	43.4	12.2	113.6	37.1
Fish	(4.5)	(5.2)	(10.8)	(3.6)	(36.4)	(12.1)
Wildlife	(0.6)	(0.1)	(25.7)	(8.6)	(76.0)	(25.0)
Multipurpose Reservoirs	(16.0)	(0)	(6.9)	(0)	(1.2)	(0)
ELECTRIC POWER		77		2,400		8,700
Power Plants		(77)		(2,400)		(8,700)

Table F-17
GILA SUBREGION
ANNUAL OPERATION, MAINTENANCE AND REPLACEMENT COSTS
(Cumulated above 1965 level at last year of time frame in thousands of dollars)

PROGRAM FUNCTION	1966-1980 PROGRAM		1981-2000 PROGRAM		2001-2020 PROGRAM	
	Federal	Non-Federal	Federal	Non-Federal	Federal	Non-Federal
WATER SUPPLY--MULTIPURPOSE	725	7,655	8,600	17,425	14,600	20,925
Intraregional Water Transfers	(-)	(7,500)	(-)	(13,800)	(-)	(17,900)
Surface Water Development	(-)	(-)	(-)	(25)	(-)	(25)
Water Yield Improvement	(725)	(155)	(8,600)	(3,600)	(14,600)	(3,000)
WATER QUALITY CONTROL	265	5,445	585	11,515	1,055	23,905
Conventional Waste Water Treatment	(265)	(4,245)	(585)	(9,315)	(1,055)	(20,205)
Tertiary Waste Water Treatment	(0)	(1,200)	(0)	(2,200)	(0)	(3,700)
Drainage Water Treatment	(-)	(-)	(-)	(-)	(-)	(-)
LAND TREATMENT AND MANAGEMENT	7,112	2,625	12,540	5,517	17,220	3,697
Cropland						
Erosion, Sediment and Runoff Control	(85)	(207)	(88)	(210)	(86)	(208)
Soil Survey	(-)	(-)	(-)	(-)	(-)	(-)
Rangeland						
Erosion, Sediment and Runoff Control	(1,521)	(194)	(2,493)	(254)	(3,702)	(283)
Forage Production	(581)	(138)	(795)	(172)	(1,733)	(160)
Wildfire, Prevention and Suppression	(202)	(7)	(284)	(13)	(305)	(21)
Forest Land						
Erosion, Sediment and Runoff Control	(3,512)	(1,334)	(6,256)	(3,731)	(7,631)	(1,382)
Timber Production	(155)	(70)	(330)	(20)	(320)	(5)
Forage Production	(125)	(70)	(400)	(150)	(850)	(225)
Wildfire, Prevention and Suppression	(875)	(100)	(1,800)	(125)	(2,450)	(125)
Urban						
Erosion, Sediment and Runoff Control	(56)	(505)	(94)	(842)	(143)	(1,288)
FLOOD CONTROL	418	895	193	865	606	720
Levees and Channels	(0)	(289)	(0)	(353)	(0)	(193)
Reservoirs	(123)	(322)	(0)	(203)	(420)	(98)
Flood Plain Regulation	(120)	(52)	(80)	(84)	(0)	(121)
Land Treatment	(175)	(232)	(113)	(225)	(186)	(308)
IRRIGATION AND DRAINAGE	297	12,891	286	13,612	285	14,064
Irrigation Development	(-)	(7,000)	(-)	(7,480)	(-)	(7,510)
Drainage Development	(-)	(20)	(-)	(220)	(-)	(765)
Land Preparation, Onfarm Facilities	(297)	(5,871)	(286)	(5,912)	(285)	(5,789)
MUNICIPAL AND INDUSTRIAL WATER	-	1,700	-	3,300	-	6,200
RECREATION	5,700	5,000	23,700	12,400	34,700	25,700
FISH AND WILDLIFE	1,600	500	3,950	1,200	9,810	3,250
Fish	(975)	(325)	(1,050)	(350)	(2,175)	(725)
Wildlife	(225)	(75)	(2,550)	(850)	(7,575)	(2,525)
Multipurpose Reservoirs	(400)	(100)	(350)	(0)	(60)	(0)
ELECTRIC POWER	-	1,700	-	132,600	-	561,400
Power Plants	(-)	(1,700)	(-)	(132,600)	(-)	(561,400)

PROGRAM EVALUATION

CHAPTER G - PROGRAM EVALUATION

The comprehensive framework program responds as nearly as practicable to the projected needs of the social and economic activities of the Region. However, for some program activities it is not practicable to satisfy all needs. Some water-related activities will require further studies to more clearly define the requirements, potential programs to satisfy requirements, and the limiting effects of available resources.

Water Supply

All presently visualized, reasonable means of water conservation, salvage, and reclamation, as well as maximum utilization of the Region's surface- and ground-water supplies for which there are tangible means of evaluation and which are reconcilable from an environmental aspect, have been considered in the development of the framework program to meet future needs. Where other recognized possibilities exist, further study has been recommended to develop adequate information to evaluate the potential. With the incorporation of all known, practicable water conservation means and development of water sources within the Region, it appears there will remain a significant regional water deficiency that can be met only through importation from outside the Region.

At this time, a finite value is difficult to place on the water deficiency because of the large number of variables involved and the lack of sufficient data. To develop a framework program, using available data which reflect the order of magnitude of facilities and costs, numerous basic assumptions had to be made. One of the major assumptions was that the average annual virgin flow of the Colorado was represented by the 1906 to 1965 period of record. Although the 1906 to 1965 period was selected as representative of the average annual virgin flow of the Colorado River, other shorter periods show lower average flows. A comparison of these differences is shown in the following tabulation:

Average Annual Virgin Flow
Colorado River at Compact Point

Period	maf
1906-65 (60 years)	15.09
1914-65 (52 years)	14.64
1922-65 (44 years)	13.87
1931-65 (35 years)	13.09

It is apparent that use of the shorter, more recent periods of record would have indicated greater water deficiencies.

Because of the uncertain nature of long-term projections of water requirements, they should not be regarded as exact or final. Such projections do, however, establish the order of magnitude of future water supply deficiencies and the scope of required water supply programs. In the future, periodic assessments of the water situation will be necessary to appropriately gauge the program response.

The Region's present water deficiency will increase considerably by 1990, the earliest probable date that an importation program could be in effect. In the meantime, some water requirements will remain unmet. Under such a competitive situation, water utilization will tend to evolve toward uses offering the highest economic return, unless constrained by legal and institutional factors.

Some ground-water overdraft is expected to continue beyond year 2020, mostly in the Gila Subregion. This overdraft would occur largely as a result of agricultural development in the more remote ground-water basins; mineral developments, where surface supplies are unavailable; and water supply developments, in minor amounts for the smaller communities remote from surface-water sources. It is not likely that ground-water overdraft would be entirely eliminated, even in import water service areas where a combination surface-ground-import water supply is utilized. The annual rate of ground-water overdraft after 2020 is largely conjectural. Figure G-1 illustrates the regional water requirement and supply picture for 1965 through 2020.

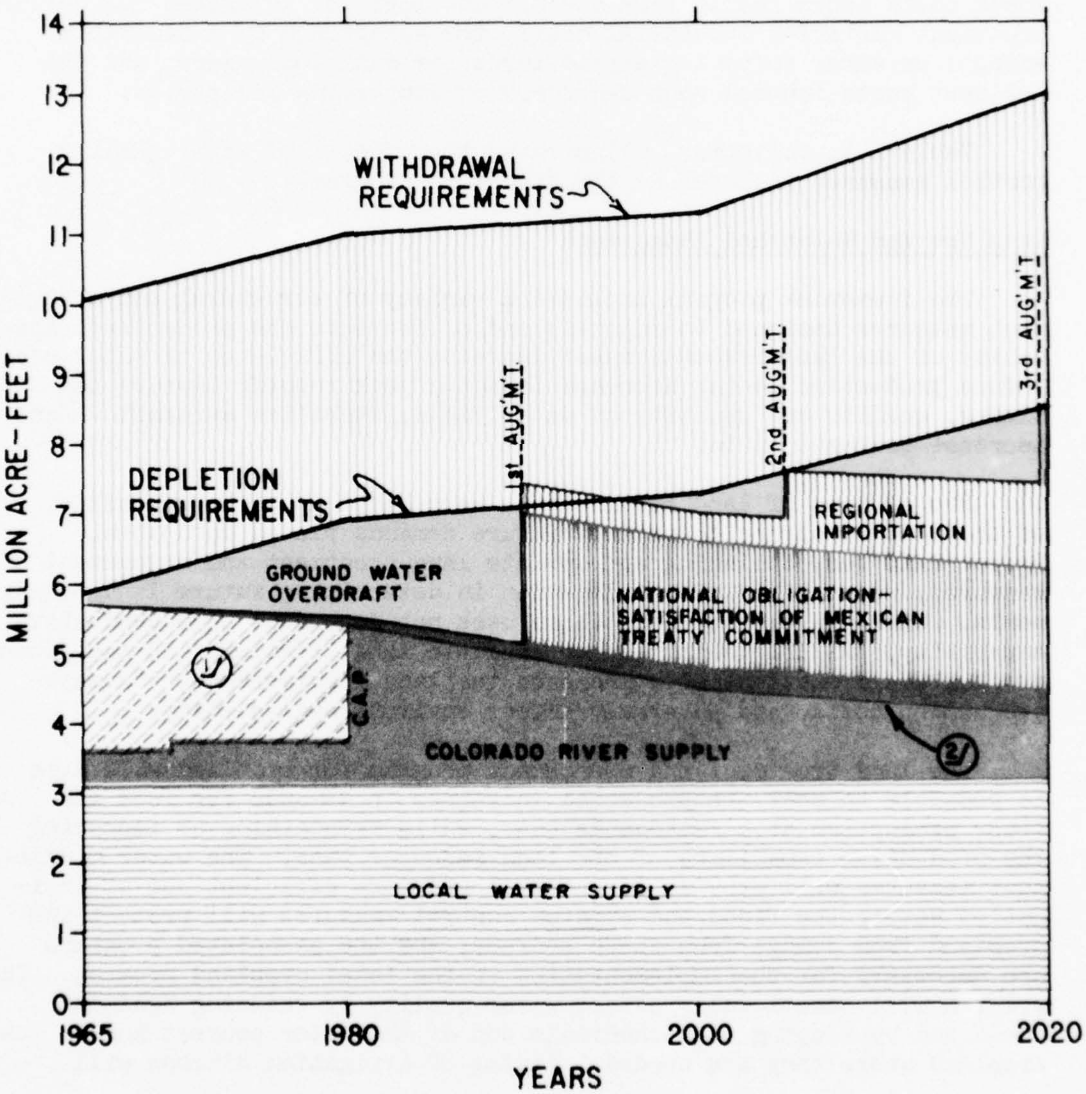
Water Quality

The maintenance of an acceptable level of water quality is particularly critical and complex in the Lower Colorado Region where maximum water utilization must be obtained by recycling available supplies. Colorado River water released to Mexico must continue to be regulated to closely approximate the quantities necessary to meet the Mexican Treaty commitment while at the same time efforts must be continued to maintain quality. The high cost of future imported water will probably dictate the continuation of an exceptionally high water-use efficiency with little or no allowance for transportation of salts or waste loads from the Region. The water quality program, coupled with an importation of high quality water to the Region, is expected to stabilize the water quality of the Colorado River water near the present level.

Negligible outflow from the Gila Subregion is expected to continue. The area having the most critical unmet need for water quality control will probably continue to be in the Gila Subregion where recycling of water results in the progressive concentration of salts that ultimately accumulate in the ground-water reservoir.

Further studies are needed to determine the extent and rate of water quality degradation to be expected under various operating conditions, to examine the alternative solutions to the problems, and to

FIGURE G-1
PROJECTED WATER REQUIREMENTS AND SUPPLY



1 AVAILABILITY OF COLORADO RIVER WATER AFFECTED BY LACK OF DIVERSION FACILITIES. REQUIREMENTS ARE MET BY GROUND WATER OVERDRAFT

2 WITHIN REGION AUGMENTATION.

evaluate the consequences of various alternative levels of water quality control measures.

Without augmentation and/or salinity control measures, the penalty costs of the Colorado River water salinity to Lower Colorado and California Region economies may exceed $25 million annually in 2010 and even greater amounts by the year 2020, according to a recent study. 1/ These costs would result from yield reductions for irrigated agriculture, treatment costs for industrial users, the acceptance of undesirable effects or water softening expenditures for municipal users, and the indirect costs imposed upon secondary or supporting industries.

Table G-1, following, illustrates the effects of water quality control measures included in the framework program.

Land Use and Watershed Management

The framework program includes a variety of structural and management measures designed to maintain and/or increase the productive capability of the land resource base; increase the efficiency of water use; reduce production costs; decrease damaging peak runoff; improve the timing, quality and quantity of water yield; stabilize streamflow; and decrease sediment yield.

Projections of land requirements were based upon the capability of the land resources to satisfy future demands placed upon them. Proper land use, including appropriate land treatment and management measures, was the basic consideration in determining future land requirements. With the exception of those uses not dependent upon productive capability, failure to install an adequate land treatment and management program would substantially increase the land requirements, increase production costs, and adversely affect environmental quality.

The land treatment and management program for cropland will make it possible to meet the projected increases in demands for food and fiber production at a reasonable cost, while maintaining or improving the productive capability of the land resource base. The water management measures will provide for control and more efficient use of irrigation water; the flood and erosion control measures will protect the cropland from damage from these sources; and the associated programs are necessary for the implementation of the total cropland program. The program will beneficially affect water quality by reducing sediment yield and by keeping farm chemicals out of the water courses and on the cropland where they are needed. Lining of irrigation ditches will

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1/ Under preparation by EPA.

Table G-1
Projected Concentrations of Total Dissolved Solids
in the Lower Colorado River
(mg/l)

Location	1965	1980 Without Program	1980 With Program	2000 Without Program	2000 With Program	2020 Without Program	2020 With Program	Percent Increase 1965-2020 Without Program	Percent Increase 1965-2020 With Program
Colorado River									
At Lee Ferry, Arizona	586	650	560	760	580	820	630	40	8
Below Hoover Dam	734	950	860	1,010	810	1,050	850	43	16
Below Parker Dam	726	980	870	1,140	870	1,150	880	58	21
At Imperial Dam	839	1,260	1,100	1,290	980	1,350	1,030	61	23

reduce water losses, and will help prevent pollutants dissolved in irrigation water from reaching the ground water.

There will be increased use of the rangeland for recreational and other purposes. This intensified use will create protection and management needs that do not presently exist. At the same time there will be a need for increased forage production from the rangeland because of the significantly increased livestock production projected for the Region. The program for rangeland is designed to protect the land base while satisfying as much of these demands as possible.

The proper use and management of forest land will have the effect of reducing the cost of producing forest resources, and will result in effective multiple use of forest areas. Much of the current damages to the forest resource will be corrected to reestablish the quality of this resource and to prevent further degradation of the forest environment.

The program for water yield increase involves only forest land and may,if properly carried out, increase domestic livestock forage and give added protection to the soil thereby decreasing sediment production. However, removal of phreatophytes may be detrimental to some species of wildlife.

Total average annual sediment yield for the Region, considering the projected yield with no program, would be reduced by about 8,500 acre-feet by 2020 with the going program. The recommended program would further reduce this yield to about 11,000 acre-feet per year.

The program will significantly decrease deposition of sediment on agricultural lands, in reservoirs, and in urban areas. Additionally, the program will beneficially affect water quality by reducing sediment content, and would thus enhance fish and wildlife habitat, increase recreation values, and reduce costs of water treatment for irrigation, municipal, and industrial uses.

The program will be effective in reduction of land loss from gully and streambank erosion; give protection to a major portion of lands presently being damaged, and provide protection to improvements, equipment, and public facilities. Eroded lands often mar the beauty of the landscape and degrade the quality of the environment. The program will substantially reduce this type of damage.

Since total reduction of erosion damages is neither physically nor economically feasible, erosion control structures were considered for only the most critical areas, where either onsite or downstream damages are significant.

Flood Control

Flood control is desirable for the protection of every individual and every parcel of land or property that is potentially endangered by floods in the Region. However, the localized but often high intensity storms, the broad and undefined flood plains, and the flash-flood type of runoff inherent to the desert areas present unique flood damage problems. Flood producing storms may be of considerable number at certain times of the year, but are unpredictably scattered and variable in intensity.

Flood damages have and will continue to increase due to recent and projected future population increases and continued economic development in the flood plains. There will be remaining damages after implementation of the program because it is impracticable to provide protection against all floods at all locations.

The regional framework flood control program is directed mainly toward the collective needs in areas where damageable values are of sufficient scope to justify the costs of projects. Figure G-2 shows the effects of the proposed flood control program.

Irrigation and Drainage

The framework program, including a modest net increase of 298,000 acres of irrigation development, will satisfy essentially 100 percent of the projected irrigation and drainage needs. The satisfaction of these needs will assure the regional capability of meeting the projected requirements for agricultural production.

The framework program for irrigation development will utilize only a small fraction of the Region's 36,000,000 acres of potentially irrigable land. This is primarily because of the paucity of local water supplies available for irrigation and the high cost of importing water for new irrigation development. In addition, other economic constraints indirectly impose restrictions on large-scale irrigation development.

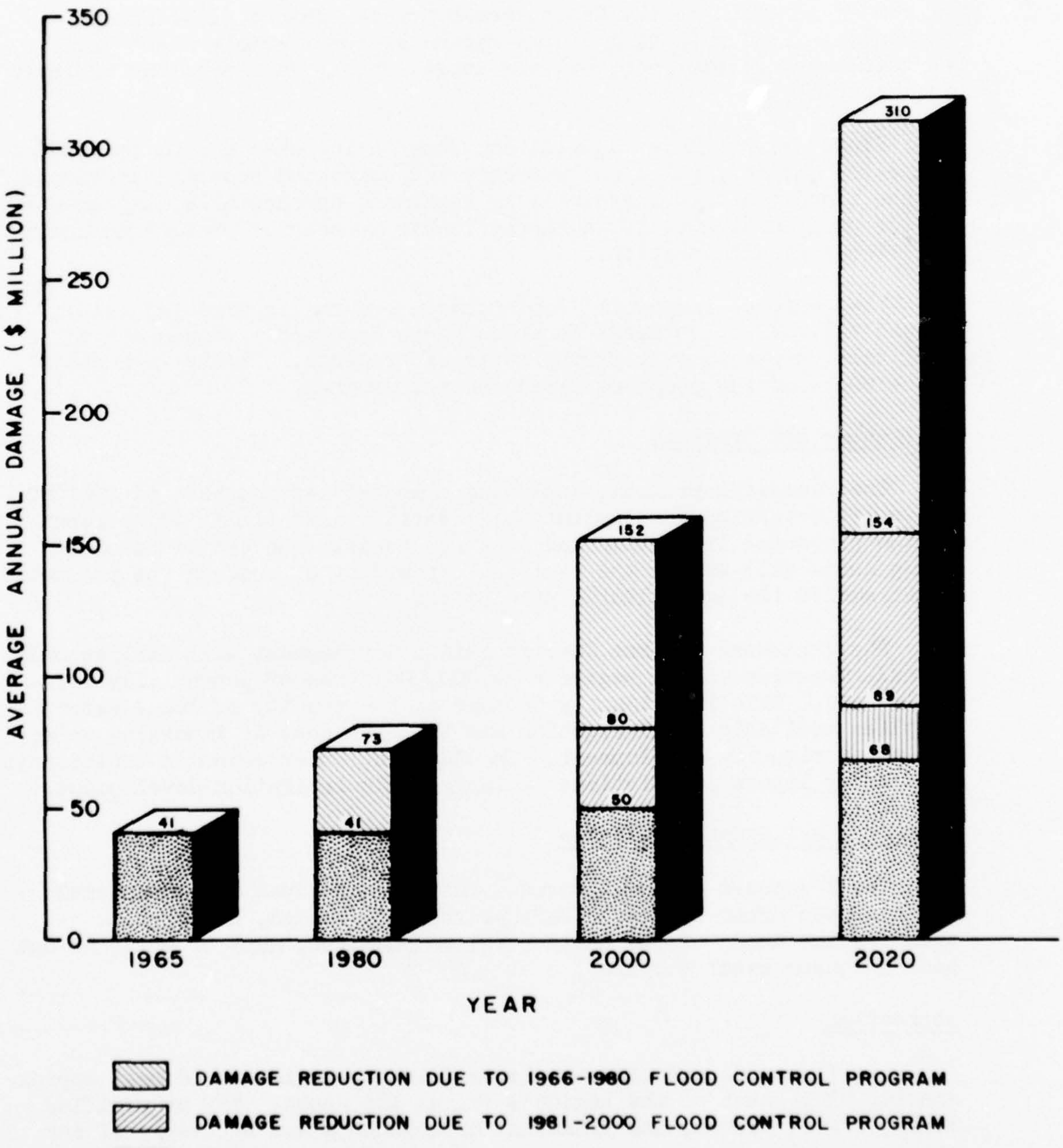
Municipal and Industrial Water

The framework program provides for the municipal and industrial needs of the urban centers. Further study is needed, however, to identify the needs of the small rural communities, many of which do not have adequate water supplies.

Recreation

The framework plan for the Lower Colorado Region would meet approximately 42 percent of the Region's recreation needs. New or modified legal, institutional, and financial arrangements are necessary if any

FIGURE G-2
EFFECTS OF FLOOD CONTROL PROGRAM
1965 - 2020



part of the remaining 58 percent of recreation needs are to be satisfied. Physical constraints, such as the shortage of surface area of water, preclude complete satisfaction of recreation needs. The distribution of population relative to resources creates part of the problem. Alternative recreation opportunities must be provided if needs are to be met.

The recreation program does not provide specific plans for facility location, but rather provides the mechanisms through which these specific plans could be developed.

Fish and Wildlife

The fish and wildlife program is formulated on the basic assumptions that the per capita demand rate will not change significantly; and that the 1965 resource base provides a sound foundation on which to construct a plan to satisfy all projected fish and wildlife oriented recreational needs. The plans and projections involving other phases of the framework program have a significant effect upon the fish and wildlife resource base. Features are included that both benefit and detract from the basic fish and wildlife resource. They may result in a species composition change or a use-type change, such as a reservoir providing a fishery at the expense of wildlife production. The ultimate need is for an expanded, well balanced, plan for the enhancement of fish and wildlife resources, especially wildlife, to meet future demands.

To determine the viability of the fish and wildlife program within the comprehensive framework program would require extremely detailed information concerning the environmental conditions of the areas to be developed. A more detailed analysis of the regional comprehensive program may indicate the need for a larger, more positive role for the fish and wildlife program.

Electric Power

Projections of electric power requirements, as provided by the Electric Power Work Group and those developed in the course of economic input-output model studies, are at variance. The economic studies indicate electric power requirements in the order of only one-third of those projected in the Electric Power Appendix for target year 2020. Such a difference in power requirements could result in about 0.4 million acre-feet less water depletion in the Region, assuming a proportionate balance between power generation within the Region and import-exports. This represents about 18 percent of the total regional increase in water depletion requirements for all uses during the 1965 to 2020 period. It must be remembered, however, that projections of electric power requirements beyond 1980 are extremely difficult to estimate, especially since a major influence is the increased per capita use, and the trend toward substitution of electricity for other forms of energy. Though there is considerable variance, and the differences have not been resolved, those

projections contained in the Electric Power Appendix have been utilized in the framework program.

Conflicts

In developing the framework program, attempts were made to attain maximum multiple use of water and related resources while enhancing the quality of life. However, in the Lower Colorado Region, the renewable water resource is inadequate to meet the existing and expected future demands. Conflicts among uses of water and related land resources exist and are expected to continue. Compromises are necessary in formulating resource development plans.

Changing technologies, needs of people, and resource situations will, to a large extent, determine the management direction and the coordination needed to foster optimum resource development. There is a limit to the amount of goods and services that the land and water resource base can yield, even with anticipated technological advances. As the demands increase for more food and fiber, goods and services, recreational opportunities, open and green space, less pollution, and better environmental quality, sound management objectives will increasingly need to be recognized and emphasized. This will require the management of all the resources for the greatest benefit of all the people.

Conflicts are inevitable in the competition for land and water resource development. The growing demands give raise to an important policy issue: natural resource use and conservation on the one hand versus the rapidly increasing demands of an affluent society on the other. All land and water resource development programs should minimize conflicts among the various preservation, conservation, development, and land-use policies. The program should provide for the coordination of all resource use and activities.

The principle of "multiple use" has come to be regarded important to good resource management. "Multiple use" is a system of planning and applying management on specific areas which attempt to achieve the protection, development, and use of its various resources so that they may be utilized in the best combination, on a sustaining basis, to meet the needs of the people. Periodic adjustments will be required to reflect changing needs and conditions.

Environmental considerations are involved in many of the more prominent conflicts as exemplified in the following:

1. Stream reaches that would be inundated by proposed water storage or flood control reservoirs often contain prime

wildlife habitat. The fish and wildlife programs are aimed at preserving this type of habitat. However, most reservoirs with permanent pools will provide a fishery which would offset some losses.

2. Phreatophyte removal and control along streams, drainage of wetlands, and stream channel improvements reduce riparian vegetation and in some cases may affect esthetics and the wildlife resource base.

3. Alteration of particular types of native vegetation is sometimes necessary for treatment of land for increased livestock forage, erosion and sediment control, and increased water yield. This tends to be detrimental to some wildlife species while benefiting others.

4. Reservoirs may occupy reaches of potential wild, scenic, and recreation rivers, and parts of designated or potential wilderness areas. It will be necessary to study and determine the need for reaches of streams to be designated as wild and scenic rivers.

5. Reservoirs, as well as many other improvements, could inundate or obliterate archeologic, cultural, or historic sites. These sites contain the key to the heritage of the past and their loss would be irretrievable.

6. Developments such as highways, transmission lines, and urban development, alter the natural environment and tend to reduce the resource base of the Region.

7. Despite advances in antipollution design and technology, thermal electric power plants cause some pollution of the environment and the growing antipathy toward such plants may become a deterrent to installation.

8. Competition among uses of available water will be one of the strongest conflicts in years ahead, particularly in the absence of adequate regional water supply augmentation. Implementation of all programs requiring a water supply would be difficult, and in some cases, impossible.

9. Urban expansion is predicted to encroach on prime agricultural land. Irrigated agriculture may be forced to develop less suitable land in order to maintain a stable agricultural economy.

10. Fish and wildlife interests have indicated that large acreages of land need to be managed primarily for wildlife. Other interests have indicated that some of these same areas need to

be managed on a multiuse basis which may conflict with primary fish and wildlife uses.

These, of course, are only a few of the issues which must be resolved. When segments of the program and alternatives are sufficiently detailed, choices can be made. Many alternatives may emerge from the recommended future studies. Improved technology may introduce new alternatives and changing economic conditions may influence future resource development.

It is important that a concerted effort be made in the early action period to resolve as many of these conflicts as possible.

Summary

Table G-2 is a summary of projected requirements, program response, and percent response, for the major sectors of social and economic activities in the Region.

Table G-2
FRAMEWORK PROGRAM RESPONSE TO PROJECTED REQUIREMENTS
Lower Colorado Region

Major Program Elements	Unit	1966-1980 Projected Requirements	1966-1980 Program Response	1966-1980 Percent Response	1966-1980 Remaining Needs	1981-2000 Projected Requirements	1981-2000 Program Response	1981-2000 Percent Response	1981-2000 Remaining Needs	2001-2020 Projected Requirements	2001-2020 Program Response	2001-2020 Percent Response	2001-2020 Remaining Needs
Regional Water Supply 1/	1,000 Acre Feet	14,895	13,410	90	1,485	14,900	14,460	97	440	16,154	15,984	99	170
Municipal and Industrial Water Supply Development	1,000 Acre Feet	837	837	100	--	1,670	1,670	100	--	2,738	2,738	100	--
Flood Damage Prevention	$ Million	73	32	44	41	152	102	67	50	310	242	78	68
Erosion Damage Reduction	$ Million	10.6	2.4	23	8.2	16.6	9.6	58	7.0	24.1	17.8	74	6.3
Wildfire Damage Reduction	$ Million	8.5	1.1	13	7.4	12.9	3.2	25	9.7	20.0	8.0	40	12.0
Irrigation Development	1,000 Acres	200	200	100	--	168	168	100	--	132	132	100	--
Recreation Development	Million Recreation Days	144	51	35	93	221	119	54	102	307	115	37	192
Fish and Wildlife Development													
Sport Fishing	Million Man-days	9.7	9.7	100	0	15.1	15.1	100	0	26.0	26.0	100	0
Hunting	Million Man-days	2.1	2.1	100	0	3.5	3.5	100	0	5.1	5.1	100	0
Electric Power Development													
Energy	1,000 gigawatt-hours	43	43	100	0	186	186	100	0	565	565	100	0
Peak Demand	1,000 megawatts	8	8	100	0	36	36	100	0	108	108	100	0

1/ Amount required to meet all obligations of the "Law of the River," Mexican Treaty, losses and regional consumptive uses.

ENVIRONMENTAL CONSIDERATIONS

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CHAPTER H - ENVIRONMENTAL CONSIDERATIONS

The Environment

A philosopher once said that a pebble thrown in the ocean would be felt on the opposite shores. Although far-fetched in the practical sense, the theory is sound and is somewhat analogous to activities and events that occur in the environment.

For instance, any development, change of conditions, or activity imposed by man onto the environment may be transmitted, ripple-like, throughout a given area--and beyond. Reaction or response among the elements of the environment may range from undetectable to strong, but they are certain to exist.

The so-called environment defies brief description since it includes all conditions, circumstances, and influences surrounding and affecting the development and maintenance of mankind as well as all other living organisms. In relation to man, it includes the availability of work for pay, living conditions, safety, recreation opportunities, material goods, services, water, food and a host of other factors conducive to existence at a given level of quality of life. The heritage of present-day and long past peoples of the Region are included within the concept of the environment. In relation to all other associated forms of nature, the environment includes the characteristics, condition and amount of land and water, habitat, vegetal cover, appearance, and the degree of exploitation of these resources by man.

Some aspects of the natural environment are highly sensitive to the slightest permanent change. These have evolved through eons of special conditions which, when upset, quickly succumb or are transmuted. The natural environment of the earth itself is transitional--continually evolving, in long-range trends, from one form to another. Man is but one among many factors in this evolution and he has the capability to accelerate, inhibit or reverse some environmental trends.

The greatest impact of man on the natural environment has been, and will be, simply his expanding population attended by increasing demands on the natural resources and living space. For each increment of increased population, there attends an increment of depreciation in the natural environment. Increasing demands of population growth are further compounded by the accelerating technological advances and the desires of an affluent society.

Trade-offs among factors of the environment must be made for the benefit and welfare of man. Not all of these trade-offs result in undesirable net effects. Many are net improvements. However, the

opportunities for trade-offs become more scarce with higher population concentrations and intensified developments. Resources tend to approach the limit of capability; space becomes limited to fewer uses; and environmental quality declines.

Therefore, in the interest of preserving the highest possible quality of environment for future generations, it becomes the obligation of all long-range planning to carefully weigh the impacts of proposed development on the multifaceted environment. Planning should strive to avoid the unnecessary, irreversible destruction of any element of the environment. Where possible, the remaining resources should be carefully enhanced, preserved and managed to prolong availability in the highest possible quality.

With these concepts in mind, and to the extent of current understanding and knowledge of the subject, the comprehensive framework program objective is to strive to maintain, for the Lower Colorado Region, a continuation of the present quality of environment for the social and economic welfare of the people, while protecting and preserving the remaining resources.

Socio-economic Aspects

Proper planning in implementation of social and economic programs to prevent development of urban and rural slum areas, and to facilitate renovation of such existing areas is essential to maintenance and enhancement of the environment. Slums and urban congestion contribute to the ill health of people, the loss of self-respect and ambition, inefficiency and loss of business, filth and degradation, and to riots and related losses of lives and property. To avoid a large part of these potential conditions, it is essential that a healthy economy be maintained through resource development programs.

Water Supply and Quality

An adequate water supply of acceptable quality is a basic requisite to implementation of many of the Region's environmental programs. For example, the fish and wildlife program requires water for development of fisheries and associated uses, water facilities for wildlife, maintenance and enhancement of wildlife habitat, food and cover for wildlife; the recreation program includes utilization of multipurpose reservoirs and requires water for park development, and other uses. The maintenance of good water quality in the Colorado River and its tributaries is essential to the recreation, fish and wildlife, and the overall ecology of this major river system. Until adequate water supplies are provided by imports, the Region's water deficiency will increase. Therefore, many water needs will remain unsatisfied and some deterioration of the environment related to water is inevitable. Choices must continue to be made as to the uses of the limited water supply that

would best serve regional objectives. These choices will become more difficult as water deficiencies increase. Economic efficiency alone is not an adequate measure by which to make these choices and other factors such as the long-range environmental consequences must be evaluated.

The early action program, consisting largely of the ongoing program, reflects the choices already made in the Region to minimize the adverse effects of a deficient water supply. Some elements of the water conservation program have encountered considerable opposition. This has been particularly apparent in the ongoing program for the selective removal, or manipulation, of vegetation in river channels and flood plains, for the purposes of increasing water yields and providing flood protection. Some opposition has also been expressed to the vegetative management programs on watersheds for the purpose of increasing water yields. Though there has been considerable effort to manage these programs to minimize the adverse effects on wildlife, and where possible to enhance the wildlife resource, it is contended that, in many cases, the wildlife resource base has been reduced. However, the inadequacy of existing water supplies makes it mandatory that some sacrifices will continue to be made. Though sometimes undesirable from the ecological standpoint, the Region must continue to make these choices to favor the welfare of its people.

The continued excessive overdraft of ground water, which is inevitable until an import water supply is available, also has long-range environmental consequences. The resultant land subsidence disrupts natural drainage, often causes damage to structures, and may result in irreparable damage to the physical properties of the evacuated aquifers.

The degradation of the quality of ground and surface waters has adverse environmental and ecological effects. The major water quality problem in the Region is the ever-increasing salinity of the water caused primarily by the concentration of salts due to intensive use and recycling of available supplies. The framework program includes the treatment of water from some naturally saline sources and other salinity control measures.

Land Treatment and Management

The protection of the Region's unrenewable land resources provides primary support for many of the Region's environmental objectives. The program provides for prevention of damage to the land by erosion and sedimentation, the maintenance or enhancement of grazing capacity, which in turn provides food and cover for wildlife; and the prevention of wildfire which protects wildlife and esthetic values. Implementation of the framework program would minimize irreversible losses of the land and preserve the freedom of choice for the future resource users.

ENVIRONMENT

Flood Control

Flood damage to the land resources is an irreversible loss that is detrimental to fish, wildlife, esthetic values, and the general land resource base of the Region. Flood damage to urban centers is also detrimental to the environment and well-being of the people. The portion of the program requiring flood water detention storage, levees, and channel improvements will need to be evaluated on a project basis to minimize any adverse effects on the natural environment. Alternative means of achieving the necessary flood protection while avoiding unnecessary adverse effects will need to be developed. Measures provided in the flood control program which would enhance the environment include flood plain building codes, health regulations and purchase of land, subject to flooding, for open spaces and zoning. The latter are least destructive to wildlife and should be carefully considered where practicable.

A well-balanced flood control program should consider: the effectiveness of alternative means of flood protection; the effect on water supply; the most appropriate uses of flood plain land; the effect on wildlife habitat; the effect on potential recreational use; and esthetics.

Though flood detention reservoirs cause flooding of some wildlife habitat, benefits to wildlife occur by reason of the growth of vegetation within the flood pool areas and the usual presence of some water for wildlife use. Inclusion of permanent storage pools could provide enhancement of sport fisheries.

Irrigation and Drainage

The maintenance of irrigated agriculture in the Region has important environmental implications. New irrigation development proposed in the program would occur mostly on desert lands. Irrigated lands provide food and cover for some species of wildlife and provide a cooler green belt, in the otherwise hot and dry desert environment. Adverse environmental impacts of agricultural practices, such as the use of pesticides and fertilizers, will require continued surveillance. Drainage of marsh lands has some detrimental effects on certain water-oriented ecological systems, but these marshy areas are often created by poor irrigation practices.

Municipal and Industrial Water

The users of municipal and industrial water nearly always have the ability to pay whatever cost is necessary to divert water from other uses, thus, in the competitive situation where water supplies are deficient, environmental objectives requiring a water resource base are difficult to implement. Water is also necessary to elevate the quality

of environment in our cities where the welfare of the people ranks highest in priority of consideration. Green lawns, trees, parks, and swimming pools are of even greater importance in the desert environment of the Southwest, than in more humid areas. The facilities provided by the framework program to supply municipal and industrial water present negligible conflict with desirable environmental qualities and, in many instances, such facilities will enhance the environment.

Mineral Resources

Utilization of the mineral resources of the Region is necessary for the well-being of the people of the Nation. The Region supplies about 60 percent of the Nation's copper and significant quantities of other minerals. Continued exploration and development are necessary if the Region is to continue to supply its share of the national demand. Continued vigilance will be necessary to minimize air and water pollution, scarring of the landscape, and other environmental degradation.

Recreation

The preservation of a high quality recreational environment for people to enjoy is one of the primary concerns in the recreation program. Much of the recreation program is dependent on implementation of other elements of the framework program, especially water supply and water quality. The recreation program provides for a wide range of recreational opportunities which will upgrade the quality of living in the Region.

The acquisition, preservation, and management of lands for recreational use range from urban parks to primitive and wilderness areas. Preservation features of the program include archeological and historical values, natural areas, ecology, wild and scenic rivers, and wilderness areas.

Fish and Wildlife

The natural wildlife community is a function of the amount of suitable habitat as well as the quality of natural environment. The fish and wildlife program outlined herein, if carried out, satisfies the demands for fish and wildlife resources through the year 2020. The program provides for the preservation and improvement of the most productive and unique fish and wildlife habitats, and the acceleration of developments to improve wildlife production throughout the Region.

With the projected rise in population attended by increased development and human pressure on the natural resource, it is increasingly important that well-planned management programs be strongly supported by all construction, land management, and fish and wildlife agencies to maintain the quality of the natural environment and the associated wildlife populations.

Electric Power

Electric power is a basic necessity to the well-being of the people and to the environment of the Region. Environmental aspects requiring electric energy include air conditioning to temper otherwise uncomfortable summer temperatures, pumps to deliver a major portion of the Region's present and future water supply, industrial smog control devices as well as other air and water pollution control devices, urban street lighting, and lighting to allow increased utilization of urban park facilities. The regional program provides for the projected future electric power requirements through imports, fossil-fuel thermal plants, nuclear-fuel thermal plants, and pumped storage hydroplants. Cooling towers are utilized and no water would be discharged back to the streams. Surveillance and control of thermal and nuclear pollution will be necessary. Some of the hydroelectric plant sites with the greatest potential have not been included in the program because certain sites along the Colorado River are precluded from consideration by Section 605 of Public Law 90-537 (Colorado River Basin Project Act). Further consideration should be given to the various alternatives available to meet future power demands and the relative impact of these alternatives on the environmental system.

The siting of thermal electric power plants will take into consideration the effects on air and water pollution. The location of transmission facilities will require careful selection to minimize effects on esthetical, ecological, and recreational aspects of the local environment.

NATURE AND EXTENT OF FUTURE STUDIES

CHAPTER J - NATURE AND EXTENT OF FUTURE STUDIES

Economic Studies

1. Additional analyses on how water resource development programs change employment participation rates, types of employment, income distribution patterns, educational levels, or other socio-economic factors should be initiated, particularly as related to low income, minority, and rural population sectors.

2. Studies should be initiated to assess the economic consequences of deteriorating water quality upon industrial and agricultural output in terms of how it affects the level and rate of regional economic growth and the well-being of the people.

3. Additional sensitivity analyses of alternatives and assumptions should be conducted, particularly as they pertain to efficiencies of water use, alternative cropping patterns, alternative crop yields, level of water availability predicated on 1965 conditions, and other agricultural production possibilities.

4. Studies exploring the relationships between economic activity and environmental characteristics of the Region should be initiated. Methods to measure environmental parameters in socio-economic terms are needed.

Water Supply Studies

Previous water related developments in the Region have concentrated on satisfying immediate problems. The struggle to live with deficient water supplies has often overshadowed other considerations. There has been constant and fierce competition for the available water among the expanding cities; agriculture; the mineral industry; and the fish, wildlife, and recreational interests. Recently the public interest has broadened to include a greater consideration of the social and environmental aspects.

To best serve the well-being of the greatest number of people, the future planning and development of water and related land resources must study all alternatives and evaluate all water related activities. Elements to be considered include: water quality; enhancement of fish and wildlife; protection and enhancement of areas of historical, scenic, or unique ecological values; and other environmental factors. To achieve this aim, improved methods will be required for evaluation of the environmental aspects and to establish the relative merits of alternative development opportunities. Planning emphasis should be oriented to

comprehensive resource development and to the preservation and enhancement of natural resources.

The development of state water plans has been undertaken by the States of the Region. These studies and the framework studies have supplemented each other. As the development of the state water plans advance, a close working relationship with future Federal planning programs should continue so that they are interrelated to best serve the interests of the Region.

The Western United States Water Plan Study as provided for in Title II of Public Law 90-537, Colorado River Basin Project Act, is a vehicle for the continued broad comprehensive water resource planning to forestall the impending water crisis in the West. The Act provides for a final reconnaissance report to be submitted on or before June 30, 1977.

Of primary importance to the Lower Colorado Region, during the 1965 to 1980 period, are detailed studies of the means by which the Region's water supplies may be augmented. The studies should be in sufficient detail to provide a basis for project authorization. The early action program should include studies of the effects of ground-water overdraft in the critical areas and the extent of irreversible damages to be expected if overdraft continues. Ground-water basins outside the present critical areas should be investigated as potential interim sources of water that might be conveyed to areas of need. The possibility of relocating some irrigated agriculture displaced by urban development and by depletion of ground-water supplies to outlying ground-water basins should also be investigated. Since development costs would undoubtedly be high, assurance would be needed as to the long-term yield of these basins and the prospects for capital recovery. Studies should be continued in the fields of reuse of water, precipitation management, and evaporation suppression. Although these augmentation means are not expected to offer a large potential for solving the Region's water problems, they could help reduce importation requirements and provide an interim water supply until an imported water supply can be made available.

Studies of the technical problems associated with the importation of water to the Region should be initiated immediately. Existing legislation will, for all practical purposes, limit these studies to desalination until the year 1978. More reliable data are needed for estimating cost of desalting water in the large quantities that would be necessary to satisfy projected regional water requirements. A prototype desalting plant of much larger capacity than those presently in operation could provide the needed data. Potential plant sites, conveyance routes, and water exchange schemes should be investigated in considerable detail.

An inventory is needed of the sources, quality, and sufficiency of water supplies available for use by the small rural communities of the Region.

Water Quality Studies

Studies of the quality of the ground water from aquifers in the Gila Subregion are of particular importance. The exceptionally efficient use of water in the Subregion allows only insignificant outflows from the area, and due to the nondegradability of the salts present in the natural water supplies, this condition perpetuates the progressive concentration of salts and the degradation of ground-water quality. Studies should determine the rate of degradation to be anticipated with the projected rates of ground-water overdraft and with augmentation programs of variable scope. Alternative solutions to the degradation problem should be evaluated. Additional studies are also needed of alternative means of waste water treatment and disposal to provide for the most efficient reuse of this reclaimed water. Evaluation of the anticipated degradation of water quality in the Colorado River and how an imported water supply could best be managed to alleviate this degradation is also needed. Also salinity studies need to be programed.

Land Treatment and Management Research

Studies to refine the information on the current watershed conditions, soil types, erosion susceptibility, sediment yield rates, and contribution to salinity in streams are essential to effective planning and management.

More detailed river basin studies are needed to identify and evaluate individual projects. Among the studies needed are the Santa Cruz-San Pedro River Basins, and the Salt, Verde, Gila, and Agua Fria drainage areas. Studies are also needed along those major river flood plains with riparian vegetation to determine impact of and potential for a vegetative management program for increased water yield.

Research is essential to provide direction for installation of a complete watershed and land resource management program which will assure maximized benefits. Research is needed not only for investigations into the specific factors affecting management of each individual resource, but also needs to be aimed at the various combinations of products and values to determine their interactions before and after management treatments. Examples of research needs are:

1. The effects on water yield from vegetative management within specific vegetative types. Evaluate the impact of this treatment on other multiple-use values.

2. The effects on surface supply and ground-water recharge of runoff control and floodwater retarding structures.

3. Improve snow data collection techniques and runoff prediction formulas.

4. Develop more selective and acceptable pesticides and herbicides and better define the limitations of those presently used. Alternate management tools need additional investigation.

5. The effects of man's activities and land treatment and management on associated fish and wildlife, both game and nongame.

6. Improve timber management systems, develop superior genetic strains of timber, and find more efficient methods to use forest products.

7. Improve techniques for inventorying resources, measuring resource conditions, and organizing resource data for more meaningful interpretation and utilization in management decisions.

Flood Control Studies

The magnitude of the flood problem indicates the need for a research program for flood damage reduction. Specific suggestions for more detailed studies include:

1. The problem of urban hydrology should be studied. Because of rapid urbanization, greater runoff occurs in these areas.

2. Since a large part of the Region is in an arid area, a study should be made of desert hydrology.

3. Research to determine the potential for storing floodwater in underground reservoirs created by nuclear devices and the fracturing of rocks to create greater infiltration rates of percolation.

4. Research to develop better hydrologic models for flood forecasting.

5. Improve flood warning system by research in precipitation forecast through radar sounding and other means.

6. Further studies to evaluate alternative means of obtaining flood protection in specific areas should include, but not be limited to, environmental considerations, nonstructural flood plain management measures, and open space.

Electric Power Studies

The projected large increases in the demand for electric power will require investigations to determine the most suitable locations for the thermal electric power plants. Environmental considerations and availability of water for cooling will be of primary consideration. Thermal pollution is presently avoided through use of cooling towers. A pilot power plant using dry cooling towers should be constructed in the near future to evaluate the added costs in terms of the value of the water conserved. The Public Utility Commission should be urged to allow the Utility to absorb the added costs into their base rate so as to promote this research and development.

Specific reaches of rivers and flood plains, having unusual scenic or ecological qualities and other areas of historic or esthetic significance need to be identified so that they can be avoided in planning for electric power plants and transmission facilities.

Recreation Studies

Further studies should be undertaken to determine and implement Federal and state land use goals and policies. Identification of land and water available and suitable for recreation purposes should be a part of such studies. In addition, the recreation land classification system should be reevaluated and improved to provide a more efficient technique for identifying recreation resources. Land use planning should take into consideration the need to preserve unique natural and cultural features before such resources are lost to other uses.

New techniques for measuring recreation use and recreation user preference should be researched. These new techniques should be readily available to all recreation planners and management agencies and should encourage uniformity among all agencies in amassing statistical data.

Studies are needed to determine the most feasible method for banking and disseminating recreation data.

Fish and Wildlife Studies

Study is needed to determine ways of enhancing or supplying the wildlife needs of the Region during the early action period, 1966 to 1980. Little is known about the habitat needs of nongame wildlife, and little is known regarding the supply of nongame wildlife that may, by the end of the study period, become more important than the game species. Studies are also badly needed to provide ways to increase the wildlife productive capacity of the lands in the Region, particularly in the face of needs to use these same lands for supplying other resources and products to meet the projected needs.

FUTURE STUDIES

Research should be undertaken to fill gaps in life histories, population dynamics, and ecology of important species. Investigations should seek to determine the effects of streamflow regulations, land-use changes, pesticides, parasites, and diseases on fish and wildlife populations. The introduction of exotic or specialized species of fish and wildlife should be evaluated in terms of biological feasibility and the impact on recreational and commercial utilization of the resources.

Special research and management programs should be activated by 1980 to control nongame fish within existing reservoirs. As new reservoirs are impounded, they would be brought under this program.

Environmental Research

Research should be implemented to provide a systematic approach to assessing problems of the social environment.

A more comprehensive evaluation of the effects of regional water planning and management programs in terms of productive utilization of labor and capital is needed. Though economic efficiency is an important guide to the implementation of a water resources development program, other objectives must also be considered in light of today's social and economic problems. The Region, for example, contains underdeveloped areas, areas of economic depression, and in many cases, immobile work forces. Providing jobs and income to residents of these areas should be considered an important objective of the Region. Projections point to the concentration of population in a few large metropolitan centers in the Region, consequences of which should be explored. Studies which form the basis for evaluating alternative courses of action to meet such objectives, therefore, become an integral part of the comprehensive plan for development of the Region's resources.

Ecological Research

Some threatened environmental damages are obvious and dramatic, and have already caused some important water-oriented projects to be abandoned, relocated or redesigned. The more subtle, and perhaps equally significant, changes in the ecological spectrum have not been addressed, or even recognized in many instances, for lack of manpower and expert knowledge. A more detailed and precise picture of the ecological effects of water development is needed. Greater sophistication must be achieved to insure that the less obvious damages are avoided and the less obvious enhancements are achieved. Impacts far removed from the project area must also be considered in evaluating their effects on the total environment.

Archeological and Historic Investigations

A systematic regionwide investigation and assessment of the character and significance of the archeological and historic resources are needed as the basis for deciding what should be preserved for future generations, what should be investigated and salvaged prior to destruction by project activities, and which sites may be allowed to be destroyed.

IMPLEMENTATION AND FUNDING

CHAPTER K - IMPLEMENTATION AND FUNDING

Initiating the Program

The implementation of the development program to fulfill the future needs of the Region requires immediate action to accelerate programs for water resources and related land development by over threefold. Most of the early action programs are continuations of those currently underway. Though the Region has had one of the fastest growth rates in the Nation, and is one of the most critical water deficient areas, water resource development has progressed more slowly than that of most other areas. This slowness of response to the needs can largely be attributed to the sheer complexity of the problems, the magnitude of developments necessary to solve them, and the legal problems which have retarded the Region's ability to fully utilize its share of Colorado River water. While the latter has been partially resolved, by authorized projects, the others, such as funding, continue to harass the Region's efforts to meet its present needs or to implement programs to satisfy future needs. Consequently, the action programs have fallen far behind, resulting in the accumulation of a tremendous backlog of development needs. To avoid an unrealistic level of funding during the early portion of the program and to allow adequate time for the necessary comprehensive planning, a 35-year period from 1965 to 2000 is suggested as the development period to essentially eliminate the backlog of needs. The timing of a program of water importation to the Region is most critical because implementation of many other elements of the framework program is dependent on an adequate and timely water supply.

It is anticipated that a public information program will be a necessary and integral part of the early action program. It will be imperative that the public be made aware of the problems and of the foreseeable consequences created thereby; that all potentially feasible solutions be fully considered by the public; and, that time be allowed for formation of public opinion, the determination of the public desire, and public willingness to pay the cost of new developments before implementation of the proposed action program can be achieved.

Funding

The funding of existing programs would need to be accelerated by over threefold if all elements are to be completed by 1980. The $720 million Central Arizona Project, representing nearly 50 percent of the Federal portion of the regional early action program, is the principal authorized project needing acceleration.

The funding schedule needed to catch up with the Region's development needs has been spread over a 35-year period to year 2000. At that

time, the Region's backlog of needs would essentially be satisfied and the 2000 to 2020 funding program would need only to satisfy the needs arising during that 20-year period.

Table K-1, graphically illustrated in Figure K-1, provides a comparison of the present annual average level of funding with that needed in each of the subsequent time frames to achieve the water and related land resources development program.

Table K-1
Average Annual Federal and Non-Federal Program Costs

Unit: Million Dollars

Item	Present 1/ Funding Level	1965-1980	1981-2000	2001-2020
Federal Installation Costs				
Regional Programs	30	100	97	205
National Obligation, Mexican Treaty		--	163	--
Non-Federal Installation Costs		36	56	86
Federal Operation, Maintenance, and Replacement Annual Costs		66	290	359
Non-Federal Operation, Maintenance and Replacement Annual Costs		108	548	1,499

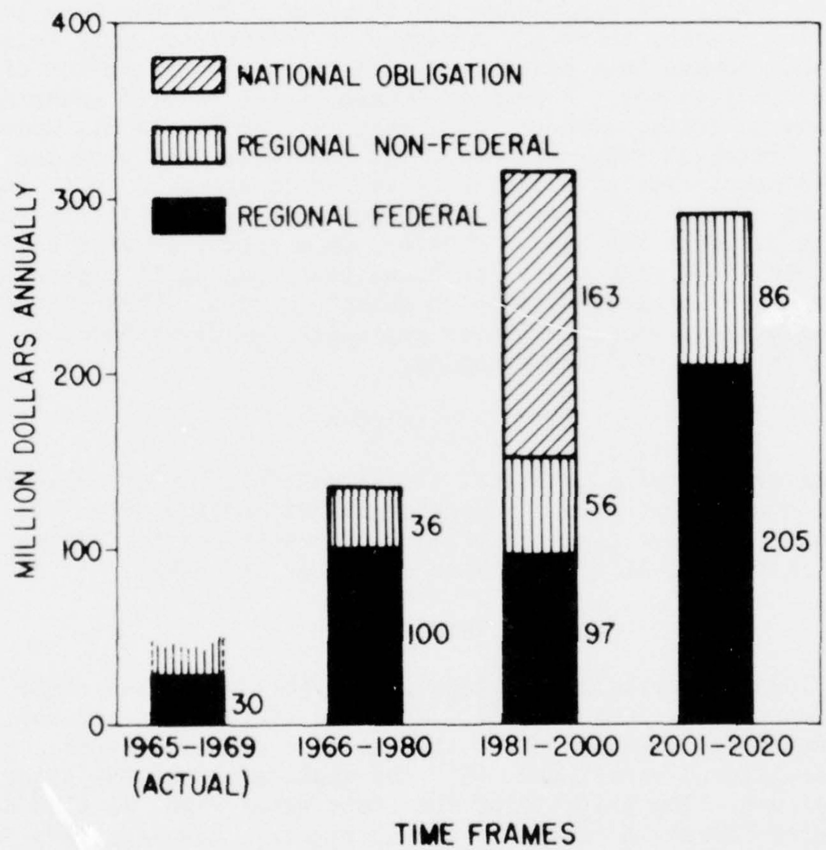
1/ Average for the years 1965 through 1969.

The division of costs between Federal and non-Federal interests was based on present legal and institutional arrangements. It has been indicated that the non-Federal portion of the recreation program could probably not be achieved unless the Federal participation is increased. It is estimated that about 70 percent of the Federal costs for the Region framework plan would be repaid.

Legal and Institutional Problems

Constraints which could delay the implementation of the comprehensive program include some of the existing policies of Federal agencies,

FIGURE K-1
ANNUAL FUNDING REQUIRMENTS TO IMPLEMENT INSTALLATION OF FRAMEWORK PROGRAM



lack of authority on the part of state and local agencies, and the constraint of financial capabilities of local agencies.

Federal-State Water Problems

Though conflicts do exist, Federal and state laws applying to water resource planning and development have been largely complementary. However, tensions have developed in the area of water law. Though historically the administration of water rights has been left largely to the states, there are a number of provisions under Federal constitutional powers that have placed the state administration of water rights in jeopardy. A recent concern is the Federal grouping of water uses on Indian reservations, national forests, etc., under the category of "reserved water rights." The theory is that when the Federal Government created a land reservation in the arid West, it reserved such amounts of water as might be necessary to utilize the land for the purposes intended. However, this theory creates an uncertainty as these rights are not quantified, making it impossible for the states to integrate them with private rights. This uncertainty as to the amounts of remaining water available for development is detrimental to water resource planning.

State Institutions

A major problem of some states is the multiplicity of organizations involved with water resources. These organizations are often overlapping and unrelated. A centralization of responsibility within the states for matters dealing with water resources is needed.

State Water Law

State laws prescribing the steps to perfecting a water right appropriation usually include: (1) a notice of intent or an application to appropriate water; (2) the building of works necessary to divert or impound water; and (3) the application of the water to a beneficial use. The priority of the state water right is then based on the rule of "First in time is first in right." However, laws of the various states differ as to (1) what may be defined as a benefical use; (2) what priority or preference may be applied to different uses; (3) the amount of water per acre that may be allowed under an irrigation appropriation; and (4) procedures for acquisition of rights. Consideration should be given as to whether greater uniformity between water laws of the various states would be desirable, and how this could be achieved.

Environmental Considerations

The field of water resources has previously been orientated toward resource development, as evaluated in rather narrow terms of economic

efficiency. Recently, environmental concepts have been widely recognized by the public. The provisions of Public Law 91-190, National Environmental Policy Act of 1969, will have an effect on Federal water resources development programs since this law requires that the environmental impact of potential developments be analyzed. New methods of evaluation are needed to properly account for the new environmental concepts. Without doubt, further state and Federal legislation governing environmental considerations will be enacted.

Legal and Institutional Recommendations of Framework Study Work Groups

During the course of the study, recommendations relating to legal and institutional changes needed to satisfy particular interests were developed in the various appendixes. Though these recommendations have not been endorsed by the Legal and Institutional Work Group, they are presented in the Legal and Institutional Appendix. Following are some of the major recommendations:

Land Use and Watershed Management--Implementation of the land treatment and watershed management program will require increased state participation in management of watershed areas where state lands are involved.

Federal legislation is needed to allow additional Federal participation in sharing the costs of installation of all land treatment and watershed management measures, and for the storage of additional water in floodwater retarding structures for the improvement of quantity, quality, and timing of water yields, and to reduce water pollution.

Land use planning needs to be accelerated for areas which are expected to be developed for urban use and effective and equitable taxing and zoning ordinances need to be implemented to direct potential developments in an orderly and esthetically pleasing fashion.

The system by which grazing privileges on public domain and national forest lands are related to certain private land holdings should be reviewed to ascertain its effect on good management practices.

Flood Control--Enabling legislation by states is needed to control the use and proper development of the flood plains. Such legislation should include, but not be limited to the following: recognition by states of the overall responsibility of flood plain regulations as a part of flood damage reduction for the health, safety, and welfare of its citizens; adoption of statewide minimum stardards for flood plain regulations; state assistance in providing technical information; state aid for acquisition of land for future projects or for preservation of open space; and state adoption of flood plain regulations based on its minimum standards for those areas where local units of government have not adopted state approved regulations within a reasonable time.

IMPLEMENTATION

Irrigation and Drainage--The "160-acre limitation" reclamation law has long been recognized as uneconomic in many areas and is becoming increasingly questionable under price cost pressures facing agriculture in recent years. Consideration should be given to substituting for this "160-acre limitation" provision in reclamation law an "acre-limitation," based on a productivity classification of project lands.

Other problems facing agriculture are changes in water law establishing "priorities of use." The conversion of irrigation water to other uses could create many problems for the irrigation interests, for urban areas, and for state and local governments.

Recreation--Implementation of the framework program for recreation will require legislation to amend existing statutes governing Federal participation in recreational activities; to establish new statutes providing for Federal funding; to establish new Federal and state land use policies and goals; and to establish funding and administrative authority relative to beautification, conveyance of Federal surplus lands for recreation purposes, water and sewage treatment facilities, and other water quality control measures.

State legislation needed would include laws establishing state land use policies recognizing the multiple-use management principle; making state lands available to local entities for recreation uses; enabling and strengthening zoning statutes; and requiring grazing lessees to permit public access for recreational purposes.

Fish and Wildlife--Fish and wildlife implementation would benefit by state legislation providing means for funding fish and wildlife enhancement, in addition to licensing fees; and establishing procedures, administrative authority and funding, for coordination of water resources planning with management for fish and wildlife resources, including the promotion of commercial fisheries.

Water Quality--There is an increasing awareness, in the Colorado River Basin, that the problems associated with water quantity cannot be divorced from the water quality problems. Water quality problems of the basin are currently being defined by the cooperative efforts of local, state, and Federal participants in the abatement conference proceedings on the Colorado River Basin under the authority of the Water Quality Act of 1965. The search for solutions to the water quality problems, so defined, must necessarily extend to an examination of existing legal systems and institutional arrangements to determine their efficacy in implementing any proposed plan for the management of water quantity and quality.

ALTERNATIVE LEVELS OF DEVELOPMENT

CHAPTER L - ALTERNATIVE LEVELS OF DEVELOPMENT

The previous chapters of this appendix have dealt exclusively with modified OBE-ERS projected levels of development. These projections were based upon regional review and modifications of the March 1968 projections (OBE-ERS) which were furnished to the Region by the Water Resources Council and are considered to be in the median range. Additional revisions to the population projections were provided by the Office of Business Economics in June 1969.

OBE-ERS Projections, March 1968

The differences between the OBE-ERS projections for the Region and those used in developing the regional framework program are minor, especially in view of the unpredictable changes in trends that are inherent in any projection dwelling 30 to 50 years in the future.

However, the differences between some elements of the projections for the Lower Main Stem and Little Colorado Subregions are of greater significance.

In the Lower Main Stem Subregion there is a major difference in the population projections of the Las Vegas, Nevada area, with the economic growth being largely recreation and tourist oriented. The water-oriented recreational opportunities afforded by Lakes Mead, Mohave, and Havasu on the Colorado River and the increasing popularity of the lavish entertainment facilities of Las Vegas, Nevada, have accounted for a rapidly increasing population growth. The population of Clark County, Nevada, has more than doubled between 1960 and 1970 and in Mohave County, Arizona, population has more than tripled. The land availability coupled with the water conveyance and treatment facilities now under construction to serve Las Vegas will probably support a continuation of a high growth rate through year 2000. The resulting difference between the modified OBE-ERS projections and the 1968 OBE-ERS projections for the Lower Main Stem Subregion is largely a matter of timing. The modified projections would require a more rapid rate of water related development until year 2000, and then a reduced development rate until 2020 as the two projections converge to within 15 percent of each other.

There are also significant percentage differences between the 1968 OBE-ERS and the modified OBE-ERS projections for population and irrigated agriculture in the Little Colorado Subregion after year 2000. However, the numerical differences are not large. The increases are largely in McKinley County, New Mexico, and are attributed to economic advances by Indians, extended development in uranium, anticipated coal development,

and increased employment opportunity caused by anticipated increases in travel along the Interstate Highway System. The projected increase in development of irrigated land in the Little Colorado Subregion is attributable to small new irrigation development on Indian lands in McKinley County, New Mexico.

The effect of the difference between the two projections on the framework plan is minor. The difference in the water depletion requirements for all uses in the Subregion is only 40,000 acre-feet.

Table L-1 summarizes the regional demand for water and related functions and services to satisfy the 1968 OBE-ERS projections. Comparisons of significant elements from the 1968 OBE-ERS projections and modified OBE-ERS projections are shown by percentages on Table L-2.

The modified OBE-ERS level of development would result in increases, above that for the OBE-ERS level, in the depletion requirements for the years 1980 and 2020 amounting to 5 percent and 7 percent, respectively. The corresponding increase in the economic final demand for goods and services would be 11 percent and the labor requirement would be larger by 12 percent in year 1980. By year 2020, the modified projections would be 9 percent greater for economic final demand for goods and services and labor requirements would be 7 percent greater than with the straight OBE-ERS projections.

The 5 percent difference between the two projections for regional water requirements in 1980 would have no effect on the early action program but would result in a reduction of ground-water overdraft from the 1.4 million acre-feet associated with the modified OBE-ERS projections to 1.1 million acre-feet. The need for an imported water supply by year 2000 would remain unchanged. The regional portion of the importation could possibly be delayed a few years under the OBE-ERS projections, but a 5-year delay would be about the maximum extent. With the uncertainties of projections 30 years in the future and the many difficulties inherent in the planning and construction of a project of this magnitude, concern for such minor variance is unjustified at this time. As future studies are made, the projections will probably be updated periodically according to the most recent trends.

OBE Projections, June 1969

The Office of Business Economics issued revised population projections in June 1969. The Lower Colorado Region framework study had progressed beyond the point where further changes in projections could be accommodated. However, these projections were examined and found to reflect major differences in projected population growth.

A comparison of the modified OBE population projections, the OBE March 1968 projections,and those issued June 1969 is shown in Table L-3 and shown graphically in Figure L-1. As shown in Figure L-1, both the

Table L-1 - Demand for Water and Related Functions and Services
OBE-ERS Projections
Lower Colorado Region

	1965 Base	Total Annual Demand 1980	2000	2020
WATER SUPPLY				
Withdrawals (1,000 Acre-Feet)				
Municipal and Industrial	450	750	1,447	2,588
Irrigation	9,138	8,922	7,843	7,754
Recreation	11	20	39	68
Fish and Wildlife	196	209	301	531
Electric Power Cooling	10	37	106	435
Mineral Production	105	169	250	327
Depletions (1,000 Acre-Feet)				
Municipal and Industrial	198	319	591	1,084
Irrigation	4,626	5,698	4,903	4,965
Recreation	4	7	13	23
Fish and Wildlife	110	138	212	387
Electric Power Cooling	10	37	106	435
Mineral Production	52	84	124	160
Flood Damage Prevention ($ Million)	41	71	143	298
Erosion Damage Reduction ($ Million)	7	11	17	24
Outdoor Recreation (Million Rec-days)	138	256	503	888
Sport Fishing (Million Man-days)	4	9	13	23
Hunting (Million Man-days)	1.3	1.9	3.1	4.8
Irrigation Development	1,315	124	118	134
Irrigation System Rehabilitation	293	429	0	0
Drainage (1,000 Acres)	212	68	32	88
Electric Power (Billion KWH)	13.3	43.4	186.1	564.5
Electric Power (Million KW)	2.7	8.3	35.8	108.5

Table L-2
Comparison of Projections

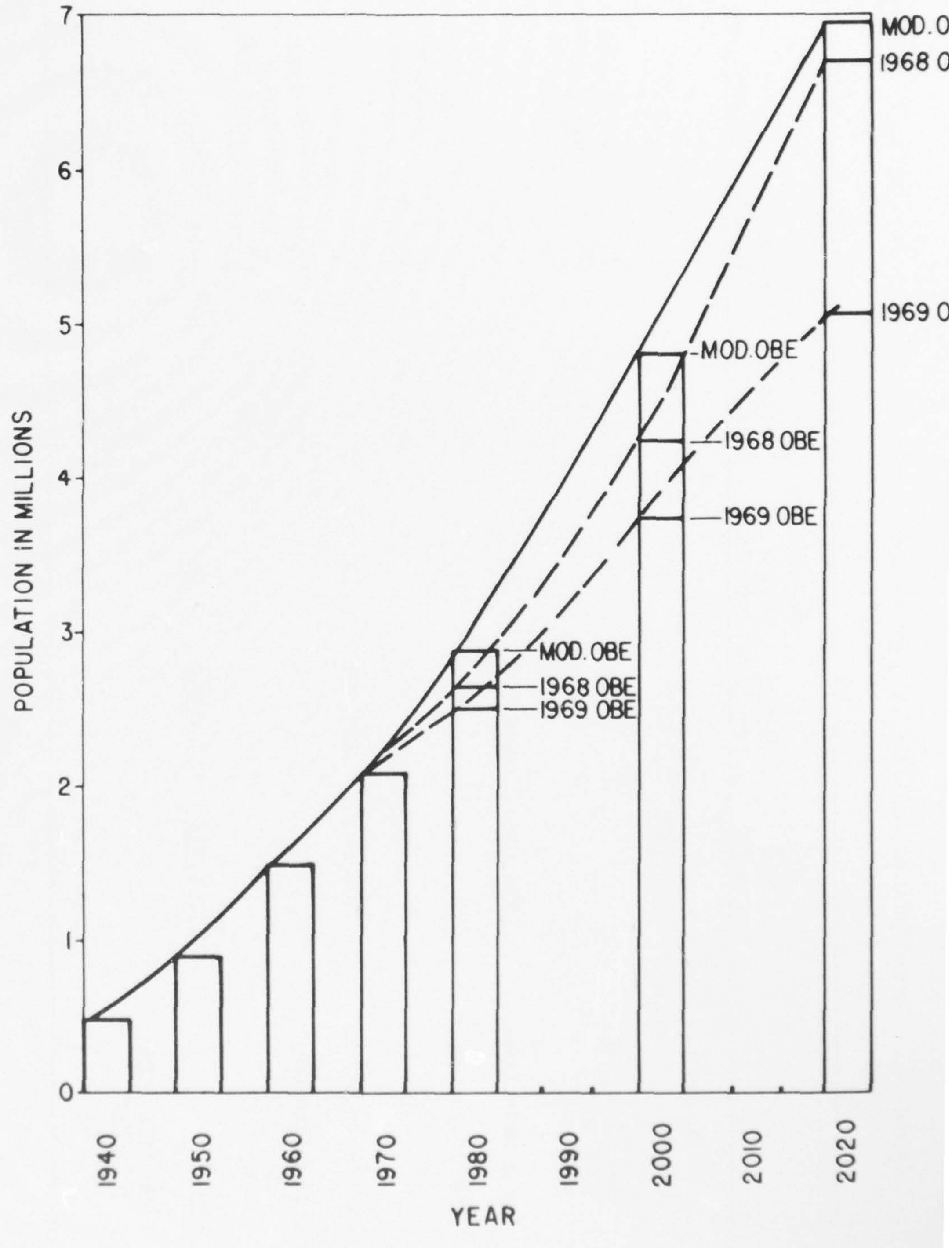
	Modified 1968 OBE-ERS Projections as Percent of 1968 OBE-ERS Projections		
	1980	2000	2020
Population			
Region	110.1	111.9	105.2
Lower Main Stem Subregion	146.6	148.5	115.1
Little Colorado Subregion	101.9	109.5	124.7
Gila Subregion	100.1	100.5	100.3
Irrigated Harvested Acreage			
Region	106	109	109
Lower Main Stem Subregion	113	106	107
Little Colorado Subregion	112	122	132
Gila Subregion	103	110	109
Water Depletion Requirements	105	108	107
Flood Damage Prevention	103	106	104
Erosion Damage Prevention	100	100	100
Outdoor Recreation (rec-days)	105	107	104
Sport Fishing (man-days)	110	115	112
Hunting (man-days)	113	113	113
Electric Power 1/	100	100	100

1/ Power Work Group projections were higher than either OBE-ERS or modified OBE-ERS and were regarded equally substitutive for each of the economic projections.

Table L-3 - Comparison of Modified OBE, March 1968, and June 1969 OBE Population Projections

	1960 Census	1970 Census	Percent Growth 1960-1970	1980 Projection	Projected Percent Growth 1970-1980	2000 Projection	2020 Projection
Lower Colorado Region	1,505,522	2,132,584	42				
Modified OBE				2,910,600	36	4,796,700	6,983,100
1968 OBE				2,644,137	24	4,263,150	6,639,165
1969 OBE				2,495,596	17	3,749,874	5,084,297
Lower Main Stem	235,546	424,524	80				
Modified OBE				815,600	92	1,519,700	2,020,500
1968 OBE				526,146	24	1,023,192	1,756,024
1969 OBE				479,300	13	751,800	1,018,900
Little Colorado	105,641	123,221	17				
Modified OBE				183,500	49	240,400	326,400
1968 OBE				180,000	46	219,600	261,700
1969 OBE				180,500	47	212,900	238,700
Gila	1,164,335	1,584,839	36				
Modified OBE				1,911,500	21	3,036,600	4,636,200
1968 OBE				1,907,900	20	3,020,400	4,621,500
1969 OBE				1,835,800	16	2,785,200	3,826,700

FIGURE L-1
COMPARISON OF PROJECTIONS OF POPULATION GRO



1968 and 1969 OBE projections of the 1980 population indicate a substantial decline in rate of growth between 1970 and 1980 then increasing again after 1980. The projections issued in June 1969 would indicate a slower rate of growth in the next 10-year period than has occurred in any 10-year period since 1940 and that the 1970 to 1980 rate would be only 40 percent of the 1960 to 1970 rate. This seems unreasonable in view of the 1970 census data which rank Nevada and Arizona first and second, respectively, among the states in rate of growth over the past 10 years. In Clark County, containing most of Nevada's share of the Lower Colorado Region population, the census count was 112 percent above 1960 with population increasing from 127,000 to 270,000. Arizona showed an increase of 35 percent over the 1960 census with the population increasing from 1,302,161 to 1,752,122 in 1970. The Region's total 1960-1970 population increased 42 percent. The growth rate of the Region would need to slow to 17 percent for the next 10-year period to stay within the June 1969 projections. The discrepancy is greatest in the Lower Main Stem Subregion which has been experiencing a recent growth boom centered largely in the recreation, retirement, and entertainment sectors. The Lower Main Stem Subregion 1960-1970 population growth rate of 80 percent would need to slow to 13 percent for the next 10-year period to stay within the June 1969 projections.

As projections delve farther into the future, the uncertainties increase many fold and projections will need to be kept up to date with the latest trends as they develop. The Lower Colorado Region is endowed with an adequate land resource and a favorable climate and if provided an adequate water supply, it is not foreseen that population growth would be constrained more in the future than in the past.

Economic Analysis of Alternative Levels of Water Supply

An analysis was made to evaluate the economic significance of increasing or decreasing the level of water availability as compared with the annual requirements computed by use of the OBE-ERS projections for year 2020. A value of plus or minus 500,000 acre-feet was used in the analysis for the Lower Main Stem Subregion, and plus or minus 1,000,000 acre-feet for the Gila Subregion. A similar analysis for the Little Colorado Subregion would yield insignificant effects.

Two alternative projections were made for each of the two subregions using the increased level of water availability, and two also at the decreased level using two sets of assumptions. The first set of alternatives postulated that the assumed increase or decrease in water availability would be shared proportionately by all water users. The second set of alternatives was based on the hypothesis that the increase or decrease in water availability would affect only those water uses contributing the least economic return per unit of water used directly and indirectly. The low-return water uses include: (1) forage, feed, and food; (2) feeder livestock; (3) cotton; and (4) all other agriculture.

Lower Main Stem Subregion

The reduction or increase of water use by 500,000 acre-feet, to be distributed in the same proportion as uses projected in the OBE-ERS projections for year 2020, would result in a corresponding reduction or increase in the economic final demand by $6.8 billion (33 percent), and in labor requirements by 220,000 man-years (34 percent).

If the water reduction or increase was confined to those sectors making the smallest contribution to the economy, the corresponding reduction or increase in economic final demand would be $86 million (4 percent) and the labor requirements would be 2,100 man-years (3 percent).

Gila Subregion

In the analysis of a water reduction or increase of 1,000,000 acre-feet to be distributed in proportion to the uses projected in the OBE-ERS projections for year 2020, the corresponding increase or decrease in economic final demand would be over $9.9 billion (24 percent), and for labor requirements would be 394,000 man-years (24 percent).

If the water reduction or increase was confined to those sectors with the smallest contributions to the economy per acre-foot of water, the corresponding decrease or increase in economic final demand would be $175 million (about 4 percent), and in labor requirements would be 5,700 man-years (3 percent).

Regional Impact

A total reduction of 1.5 million acre-feet in water use in the Lower Colorado Region in year 2020 applied proportionately to all sectors would result in a reduction in final demand of $16.7 billion, and a reduction of 614,000 man-years of employment opportunities. The total water deficiency in the Region in year 2020, if there were no water imported to the Region, would total about 4.5 million acre-feet or 3 times the reductions analyzed. If total water use becomes limited to the available natural supply, the effects on the economy and employment opportunities in the Region would be devastating. The rural economy would be severely depressed and the social penalties would spiral.

The apparent minimum impact on the Region's economy would occur if the reduction in water usage were applied to the agricultural sectors. This analysis, considering factors of regional economic efficiency, provides only one of several studies needed to assist the Region in making future choices in the utilization of its water resources. Another important consideration, in this time of social unrest, is that a portion of the labor force in the agricultural sectors are unskilled and have but

little potential for retraining. Whether the Region's interests are best served by accepting the trend toward reduction of unskilled job opportunities, and the resultant social impacts, would need to be considered. Some additional factors which would occur because of a reduced water supply and which need to be analyzed are: the effect on local and state tax base of retiring productive lands; the effect on rural communities of reducing their economic base and employment opportunities; the inevitable population shift from rural to urban centers and the resultant increase in urban social problems; the effect on farm and irrigation district operations and revenue; loss of both private and public capital improvements; the increased demands for social services in primarily rural counties; and the effect on the national food and fiber requirements.

It is very unlikely that major reductions in water usage in selective agricultural sectors could be achieved directly by regional choice because legal and institutional constraints, especially in the field of water rights, would preclude such a direct transfer of water usage. Without a water importation program, such a reduction could occur naturally, due to economic pressures, or due to exhaustion of the ground-water resources. In this event, ground-water pumping would continue until the dropping water level made further operations uneconomical for some agricultural uses, or until the source was exhausted.

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3 WES, ATTN: WESTR	INITIALS / DATE	NOTE AND RETURN / PER CONVERSATION
4 Civil Works Divisions & Districts (1)	INITIALS / DATE	SEE ME / SIGNATURE

REMARKS

In accordance with EC 1120-2-52, the following are inclosed: (Lower Colorado Region)

a. Appendix XVIII, General Program & Alternatives June 1971.

b. Main Report, June 1971.

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E.K. Yamamoto for EMIL W. ADAM Chief, Special Studies Br - SPD	16 Aug 71
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